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# Accidents cardiaques et variations brusques de salinité chez les Poissons Téléostéens marins.

par

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## INTRODUCTION

Certains êtres aquatiques, au cours de leur existence passent normalement du milieu marin au milieu dulçaquicole ou inversement. Ces êtres ont été qualifié d'euryhalins par opposition aux sténohalins dont la vie s'écoule dans l'un de ces milieux seulement et qui ne peuvent être transportés dans l'autre sans en éprouver de graves préjudices. De tels passages sont parfois imposés par les conditions d'habitats et s'effectuent à chaque instant de leur existence, en particulier chez les animaux côtiers, et les animaux d'estuaires. Parfois, aussi ils se produisent au cours du cycle de développement à des périodes déterminées de la vie.

Les sujets subissent alors, au cours de ces changements de milieu, les effets d'un grand nombre de facteurs: salinité, oxygène, température, pression, concentration en ions  $H^+$ , courants etc. . . .

Chez les Poissons Téléostéens, le passage de l'eau de mer à l'eau douce ou inversement, provoque des variations notamment: d'abaissement du point de congélation (GUEYLARD 1924 - DUVAL 1925), de composition chimique du sang (BOUCHER-FIRLY 1935 - SECONDAT 1952), d'intensité respiratoire (RAFFY 1932 - 1950 - 1954 - 1957), d'activité hormonale (FONTAINE & OLIVEREAU 1947).

Etudiant les réactions cardiaques chez les Poissons soumis à l'influence de divers facteurs, nous nous sommes demandés quels seraient les effets provoqués par les changements brusques de salinité.

A notre connaissance, un seul travail est à signaler, relatif à ce dernier sujet. LHOTTE (1945) montre que lorsqu'une Civelles subit

un transfert brusque dans une solution notablement plus concentrée en ions  $\text{Cl}^-$  que la solution qu'elle vient de quitter, ce transport entraîne chez la jeune Anguille un ralentissement du rythme cardiaque résultant d'une augmentation du tonus vagal. La technique utilisée est très rudimentaire puisque l'auteur mesure la fréquence des battements du coeur par observation directe grâce à la transparence relative des tissus.

Reprenant ce problème par la technique électrocardiographique mise au point par l'un de nous et P. RAYNAUD (1956), nous avons expérimenté sur des Muges et des Grisets, poissons communs dans le bassin d'Arcachon.

Les Muges ou Mulets s'adaptent plus ou moins aisément suivant les espèces aux variations de salinité et on peut les trouver dans les eaux salées, les eaux saumâtres et même les eaux douces; au moment de la ponte, ils descendent à la mer et présentent de ce fait une catadromie bien marquée. Le Mulet cabot (*Mugil cephalus* LINNÉ) et le Mulet ramada (*Mugil capito* CUVIER ET VALENCIENNES) s'acclimatent particulièrement aux eaux douces et remontent loin dans les fleuves et les canaux. Le Mulet doré (*Mugil auratus* RISSO) reste en général dans les eaux marines ou saumâtres.

Le Griset (*Cantharus cantharus* CUVIER ET VALENCIENNES) est par contre un poisson qui supporte mal les variations de salinité.

Les Muges et les Grisets furent pêchés par les soins de la Station de l'Institut de Biologie marine d'Arcachon. Nos expériences ont été réalisées en juillet-août 1959 dans les laboratoires mêmes de cette station et ont porté sur 28 Muges et 8 Grisets. Les poids des Muges ont varié entre 200 et 500 grammes et ceux des Grisets entre 100 et 175 grammes.

#### DISPOSITIF EXPERIMENTAL

Les laboratoires possédant des installations en eau douce (eau de la ville) et en eau de mer, il nous a donc été aisé d'effectuer tous les mélanges désirés. La valeur<sup>1)</sup> de la mesure de la salinité, après correction de température, a été donnée par des densimètres construits à cet effet.

Les mélanges eau de mer — eau douce ont été faits dans l'aquarium même où se trouvait le sujet afin d'éviter tout réflexe du type aéro-cardiaque. Le passage brutal en eau douce a pu se réaliser en 7 à 10 minutes maximum.

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<sup>1)</sup> Des dosages chimiques de la salinité ont révélé des différences d'environ 1‰ entre les valeurs obtenues par cette méthode et celles lues aux densimètres, différences pratiquement négligeables.



L'électrocardiogramme du sujet maintenu sans compression, en particulier des régions céphaliques ou latérales, dans un grillage en matière plastique, a été enregistré suivant la technique déjà préconisée par SERFATY & RAYNAUD (1956). Un dispositif du type Beaudouin comprenant un électrocardiographe à enregistrement direct sur papier thermo-sensible et un électrocardioscope permirent de suivre en permanence l'évolution du phénomène et de fixer les phases intéressantes. Deux électrodes ont été utilisées, une étant plantée dans la région précordiale en un point judicieusement choisi, l'autre servant d'électrode indifférente. L'ensemble du dispositif a été relié à la terre. Le blocage du spot sur l'écran a permis très aisément d'effectuer des mesures de fréquence qui ont porté principalement sur l'accident ventriculaire ou déflexion R. L'ensemble de nos expériences a été réalisé à des températures variant entre 22° et 24° centigrades.

Les mesures de pH nous ont donné:

- pour l'eau de mer (bassin d'Arcachon face au laboratoire) 8,1
- pour l'eau douce (prélevée au robinet de ville) 7,9
- et d'oxygénation (méthode Nicloux-Winkler):
- pour l'eau de mer 4,7 cc par litre
- pour l'eau douce 4,9 cc par litre

Les différences obtenues entre les deux milieux sont trop faibles pour que le facteur pH ou oxygénation puisse être retenu, comme ayant une action chronotrope ou tonotrope quelconque.<sup>1</sup> Dans nos expériences, il semble donc que seul le facteur "dessalure" soit à prendre en considération.

## RESULTATS ET DISCUSSIONS

### *a — Etude de l'électrocardiogramme normal.*

Des caractères communs à tous les Téléostéens sont observés à savoir:

- 1°) un tracé pentaphasique P.Q.R.S.T. (voir tracé no 2)
- 2°) un accident T espacé de R (voir tracé no 2)
- 3°) un synchronisme rarement parfait entre les accidents respiratoires et cardiaques (voir tracé no 1)
- 4°) une arythmie plus ou moins importante.

La fréquence cardiaque évaluée à la température de 22—24°, après repos des sujets placés dans un aquarium à eau courante, est:

<sup>1</sup>) Des variations de pH ont été réalisées en utilisant l'acide orthophosphorique. De faibles variations de l'ordre de 1/10 à 3/10 n'ont pratiquement pas d'effet chronotrope. Par contre, un abaissement sensible de pH détermine une bradycardie et une polypnée très certainement d'origine bulbaire.

TABLEAU I

*Fréquence cardiaque et passage rapide de l'eau de mer dans l'eau douce: Mugil capito C. et V.*

No 19 859 - Poids: 250 gs. - t° : 24°

Heures	Salinité g. de sels p/litre	F. card.	F. resp.	Observations
11 h 15	33,6	40	108	
11 h 30		42	102	
11 h 47	↓	42	116	
12 h		42	108	
12 h 01	→	42	108	Ouverture du robinet "eau douce".
12 h 15	eau douce	44	116	
	pure			
12 h 31		50	112	
12 h 46		50	112	
13 h 25		90	128	
13 h 41		94	132	
14 h 03		98	136	
14 h 15		98	144	
14 h 56		106	148	
15 h 30		106	152	
16 h		102	120	
16 h 30		102	144	
16 h 58		94	104	
17 h 30		76	125	Diminution de l'amplitude des mouvements operculaires.
18 h		56	112	Diminution progressive de l'amplitude des mouvements operculaires, QRS plus élargi.
18 h 26		56	112	
18 h 46		52	120	Amplitude des mouvements operculaires toujours visible.
19 h		52	102	
19 h 15		52	100	
19 h 36				T inversé - Forte arythmie - Respiration non visible (voir tracé no 6)
19 h 46		A V 33 12	0	Dissociation auriculo-ventriculaire (voir tracé no 7).
20 h		A V 3 7		
20 h 10				Flutter
20 h 15				Mort.

TABLEAU II.

Fréquence cardiaque et passage rapide de l'eau de mer dans l'eau douce: *Mugil auratus*

No 20 859 - Poids- 200 gs. - t° : 20°

Heures	Salinité g. de sels p/litre	F. card.	F. resp.	Observations
12 h 34	33,5	72	120	(Voir tracé no 1.)
12 h 35	—————→	72	120	Ouverture du robinet "eau douce".
12 h 40	eau douce pure	92	108	
13 h 01	↓	116	140	
14 h 30		92	156	Amplitude des mouvements operculaires atténuée.
14 h 58		76	132	Sécrétion abondante de mucus.
15 h 15		110	148	
15 h 37		108	144	Amplitude des mouvements operculaires très atténuée (voir tracé no 2).
15 h 52		108	138	
16 h 15		102	128	
16 h 33		84	136	
16 h 46		76	136	(Voir tracés no 3 et no 4)."
17 h 04		50	112	T inversé (voir tracé no 5).
17 h 08		36	70	
17 h 10				Etalement de T.
17 h 11				Arrêt respiratoire complet.
17 h 15		60	0	Tachycardie secondaire.
17 h 17		80	0	
17 h 27		5	0	
17 h 30				Mort.



TABLEAU III.

Fréquence cardiaque et passage rapide de l'eau de mer dans l'eau douce: *Cantharus cantharus*

No 21 859 : Poids: 120 gs. - t° : 22°

Heures	Salinité g. de sels p/litre	F. card.	F. resp.	Observations
12 h 15	33,5	68	108	
14 h 35	↓	68	88	
15 h 04	→	68	88	Ouverture du robinet "eau douce".
15 h 10	12,9	74	92	
15 h 19		80	108	
15 h 27	↓			Forte mélanconstriction.
15 h 28		92	112	Arythmie très prononcée.
15 h 32		104	144	
15 h 38		112	148	
15 h 40	↓	112	140	Amplitude des mouvements operculaires très atténuée.
15 h 55	3,6	122	180	
16 h	↓	132	192	
16 h 05	eau douce pure	140	196	
16 h 09	↓	98	172	
16 h 12		104	168	
16 h 20		146	182	
16 h 50		52	80	Amplitude des mouvements operculaires très atténuée.
16 h 55		48	0	R atténué - T devient très fortement positif - P R plus espacés - Dissociation auriculo-ventriculaire - Inversion de P - T s'aplatit fortement - Forte arythmie - QRS s'étale - Disparition presque complète de P - Très forte arythmie qui s'accroît, parfois 30" à 60" sans R, R progressivement de plus en plus faible jusqu'à la mort.
17 h 08	↓			Mort.



- pour *Mugil capito* en moyenne  $47 \pm 6$  (valeurs extrêmes 42-58-nombre d'individus 10)
- pour *Mugil auratus* en moyenne  $69 \pm 4$  (valeurs extrêmes 62-72-nombre d'individus 11)
- pour *Cantharus cantharus* en moyenne  $94 \pm 8$  (valeurs extrêmes 70-112-nombre d'individus 5).

Entre des limites de 200 à 500 grammes, il ne semble pas y avoir pour les Muges de relation marquée entre la fréquence cardiaque et le poids de l'animal. Notons que le réflexe aéro-cardiaque, mis en évidence par l'un de nous chez la Carpe et la Truite, est fortement positif chez les trois espèces étudiées.

*b - Influence des variations brusques de salinité.*

La durée de la résistance lors d'un passage rapide de l'eau de mer à l'eau douce est, en eau courante, de:

- pour *Mugil capito* en moyenne de  $9\text{ h }28 \pm 2,15$  (chiffres extrêmes: 5 h 15 à 14 h 25 — nombre d'individus 10)
- pour *Mugil auratus* en moyenne  $4\text{ h }04 \pm 1,40$  (chiffres extrêmes 2 h 10 à 8 h 07 — nombre d'individus 11)
- pour *Cantharus cantharus* en moyenne  $1\text{ h }32 \pm 0,2$  (chiffres extrêmes 1 h 23 à 1 h 56 — nombre d'individus 5).

Ces résultats sont parfaitement en accord avec leur mode de vie, si l'on se rappelle que *Mugil capito* est celui qui est le plus euryhalin et *Cantharus cantharus* le plus sténohalin.

Ainsi qu'en témoignent les graphiques et les tableaux ci-dessous, le passage rapide de l'eau de mer à l'eau douce, produit un grand nombre de modifications électrocardiographiques (pour *Mugil capito* voir le graphique no 1 et le tableau I, pour *Mugil auratus*, graphique, no 2 et tableau II, pour *Cantharus cantharus* graphique no 3 et tableau III).

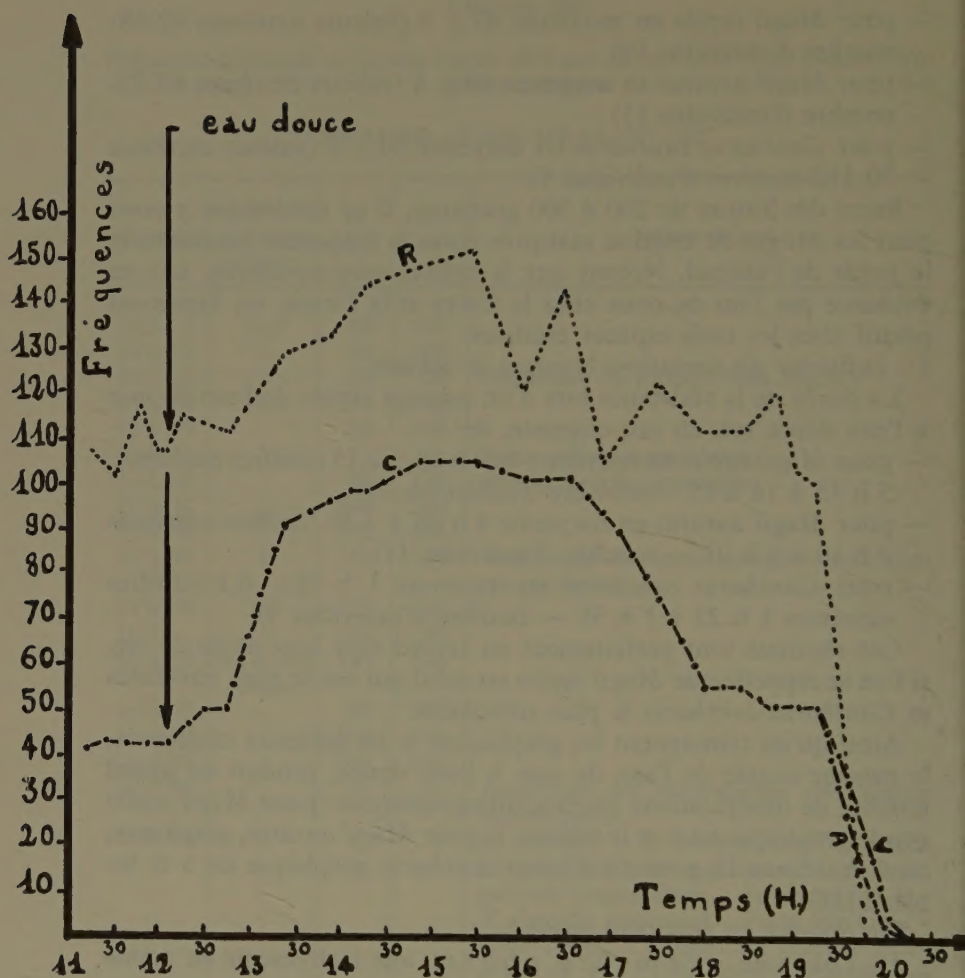
On observe en gros trois phases:

1°) Dans une première phase: une tachycardie en même temps qu'une polypnée.

La fréquence cardiaque passerait en moyenne dans le cas de:

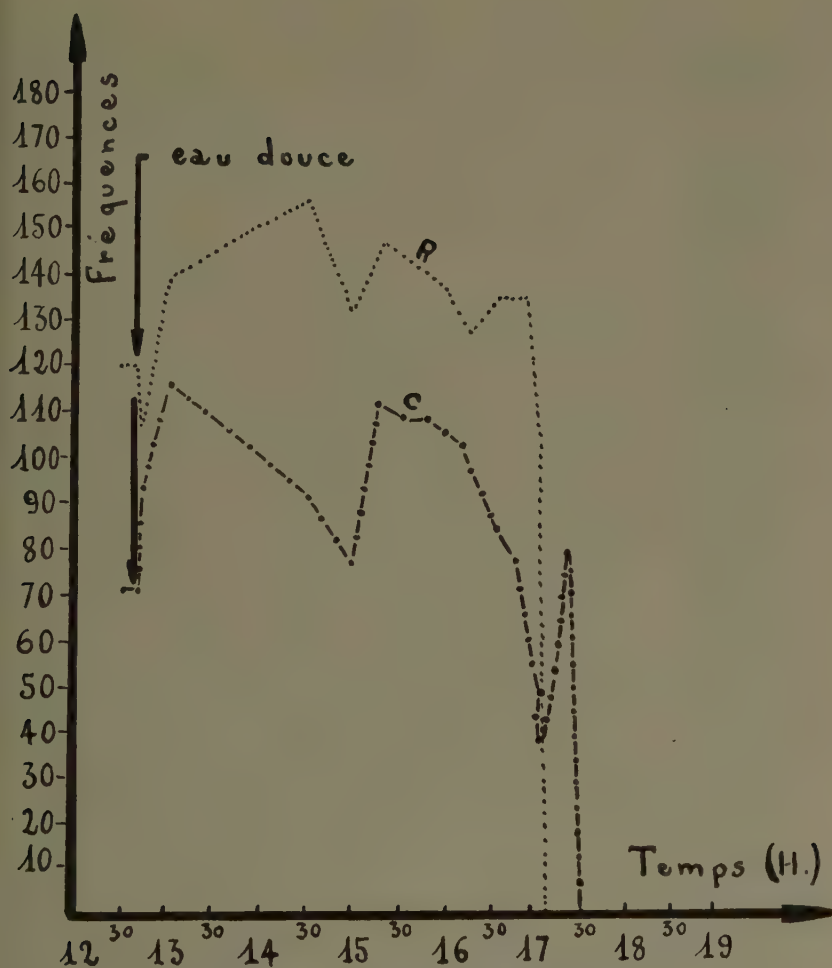
- *Mugil capito* de 47 à 103 soit une augmentation de: 123 %
- *Mugil auratus* de 69 à 102 soit une augmentation de: 47 %
- *Cantharus cantharus* de 94 à 126 soit une augmentation de: 33 %

Ces différences moyennes semblent être en rapport avec l'euryhalinité des sujets, c'est-à-dire avec leur osmo-régulation. Nous nous sommes aussi demandés dans quelle mesure le système sympathique pouvait intervenir. Il est bien connu que le système vagal régit, chez les Téléostéens, pratiquement toute la physiologie cardiaque. Au cours de ces dessalures, il ne semble pas que des excitations périphériques vagues soient à l'origine de ces modifications cardiaques. En effet, après action de M.S. 222 Sandoz, anesthésique très puissant à

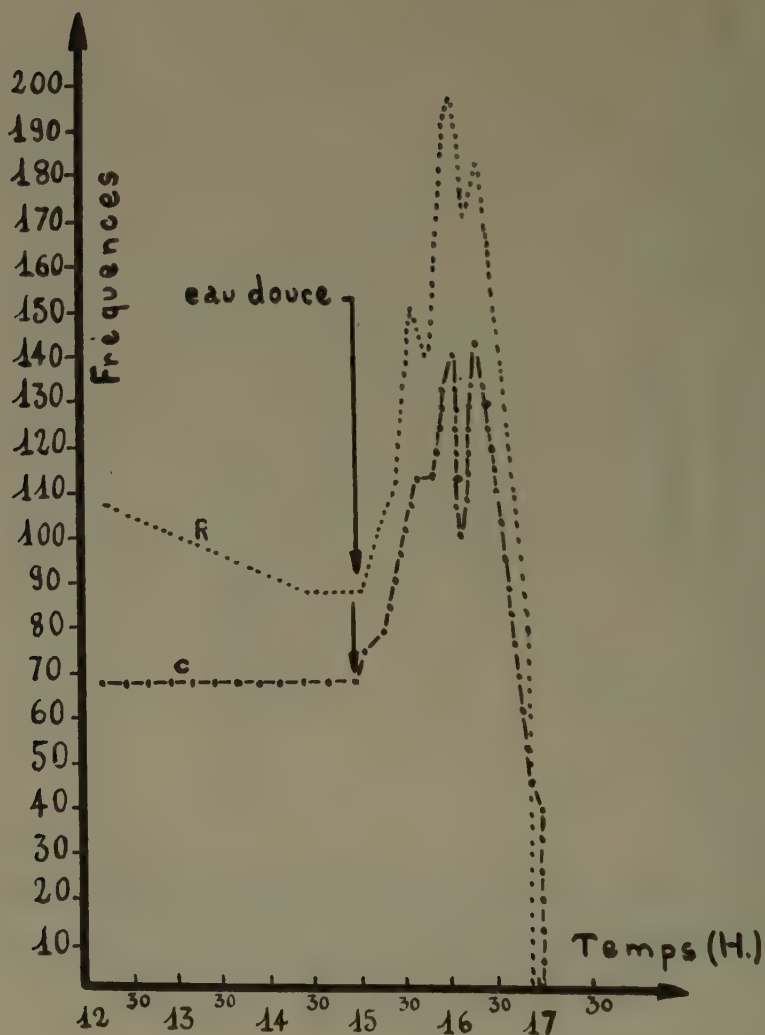


Graphique no 1 - *Mugil capito* no 19 859— $t^{\circ}24^{\circ}$ .





Graphique no 2. - *Mugil auratus* no 20 859— $t^{\circ}20^{\circ}$ .



Graphique no 3. - *Cantharus cantharus* no 21 859— $t^{\circ}22^{\circ}$ .



la concentration de 1/10 000 pendant 2 minutes et à la température de 22°, un *Mugil capito* réagit encore très nettement aux variations brutales de salinité. Une tachycardie "potamotoque" de 90 % apparaît malgré l'anesthésie.

Au cours du passage de l'eau de mer à l'eau douce, trois points ont retenu particulièrement notre attention:

- l'osmo-régulation et l'augmentation de poids des sujets surtout euryhalins,
- la tachycardie "potamotoque",
- la cardio-modération vagale.

L'augmentation de poids, observée chez *Fundulus heteroclitus* lorsqu'il est immergé en eau douce, due très probablement à la pénétration de l'eau par les branchies, suivie d'une chute de poids pourrait augmenter le volume sanguin et déterminerait une distension auriculaire. Si ces faits sont exacts, la question de l'existence du réflexe de BAINBRIDGE et de MAC DOWAL se pose. Rappelons qu'en 1915, BAINBRIDGE montra, chez les Mammifères que l'injection de solutions salines ou de sang dans le bout central de la veine jugulaire provoque une augmentation de la pression veineuse, suivie d'une accélération cardiaque. Durant ces expériences, la pression artérielle reste stable ou ne s'élève que modérément; l'accélération respiratoire n'accompagne ces phénomènes que de façon inconstante. L'accélération du rythme cardiaque consécutive à l'accroissement du retour veineux est de nature réflexe puisqu'elle ne se produit plus après section des pneumogastriques. Ce phénomène tire son origine d'influx venus du coeur et transmis par le pneumogastrique.

Peut-on établir une relation entre l'augmentation de poids due à la pénétration d'eau, la tachycardie et l'effet vagal d'origine centrale chez les Téléostéens, soumis à une très forte dessalure? Existe-t-il des baro-récepteurs dans la paroi du sinus ou de l'auricule ayant un rôle sensitif et qui seraient stimulés par les modifications de pression ou, des zones types réflexogènes sensibles aussi à des variations de même ordre? Dans le cas du réflexe de BAINBRIDGE et MAC DOWAL la tachycardie serait due à une diminution du tonus vagal par compression excessive.

Au cours du passage "eau de mer - eau douce", un second phénomène pouvant se superposer à la tachycardie serait à envisager. Un altération des branchies provoquerait une anoxie avec accumulation de CO<sub>2</sub> sanguin. Les centres respiratoires et cardio-modérateurs alors excités détermineraient de pair une polypnée visible sur les graphiques nos 1-2-3, et une bradycardie qui serait masquée au cours de la première phase par une tachycardie dominante.

2°) Dans une seconde phase, la tachycardie s'estompe progressivement; la bradycardie s'installe accompagnée d'une dimi-

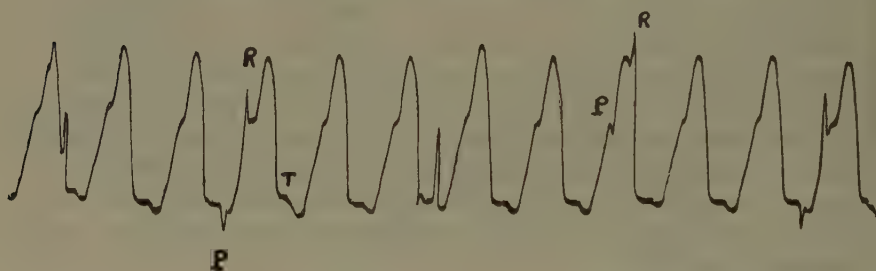
nution importante de l'amplitude et de la fréquence des mouvements operculaires.

La disparition de la tachycardie serait à rapprocher de la chute de poids corporel secondaire que l'on observe chez les Poissons euryhalins (*Fundulus heteroclitus*) au cours de dessalure très prononcée et brutale. Le réflexe de BAINBRIDGE serait amené à disparaître; la bradycardie dominerait d'autant plus que la branchie serait plus défectueuse.

L'anoxie progressant, le centre respiratoire étant de plus en plus intoxiqué, deviendrait de moins en moins sensible d'où la chute de la fréquence respiratoire. L'arrêt complet des mouvements operculaires s'effectuerait toujours avant celui du coeur ce qui signifierait une sensibilité plus grande du centre respiratoire vis-à-vis de l'intoxication par accumulation de  $\text{CO}_2$  sanguin. Le blocage des mouvements operculaires provoquerait très souvent une tachycardie secondaire prémortelle due à une forte intoxication des centres respiratoires et cardio-modérateurs.

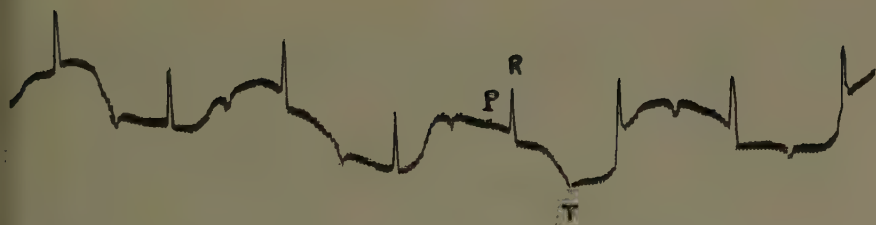
3°) Dans une troisième phase ou phase prémortelle, la forme et la fréquence des déflexions sont profondément modifiées.

En général, on observe les anomalies suivantes: une onde T à aspect acuminé, pentes abruptes, puis aplati, très souvent inversé, des arythmies de types variés (bradycardique, sino-auriculaire), un bloc auriculo-ventriculaire, un allongement de l'espace QRS et PR, à un stade très avancé, disparition de l'accident P (paralysie auriculaire) puis de QRS (voir tracés nos 1-2-3-4-5-6-7).

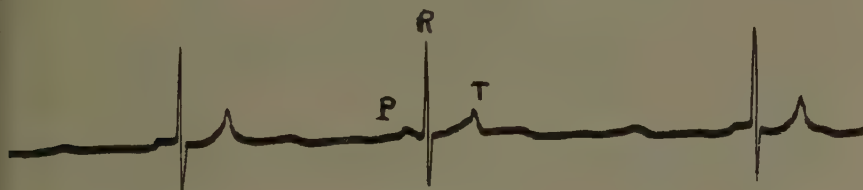


Tracé no 1. - *Mugil auratus* no 20 859: tracé montrant l'asynchronisme entre les mouvements respiratoires et les battements cardiaques. -  $t^{\circ}20^{\circ}$  (les grandes amplitudes sont d'origine respiratoires).

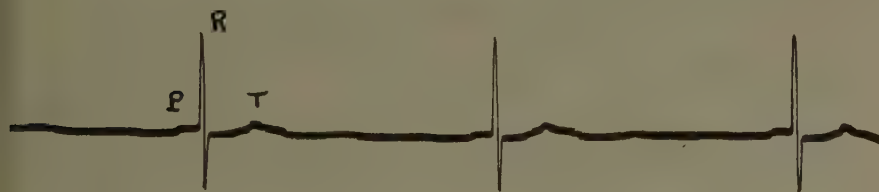




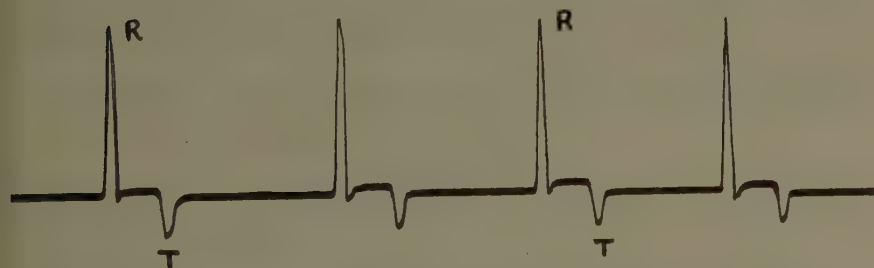
Tracé no 2. - *Mugil auratus* no 20 859: tracé pentaphasique - P.Q.R.S.T. -  $t^{\circ}20^{\circ}$  (en eau douce la fréquence des battements cardiaques est plus élevée).



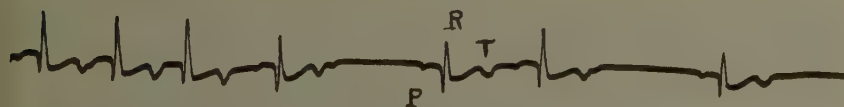
Tracé no 3. - *Mugil auratus* no 20 859: onde T acuminée -  $t^{\circ}20^{\circ}$ .



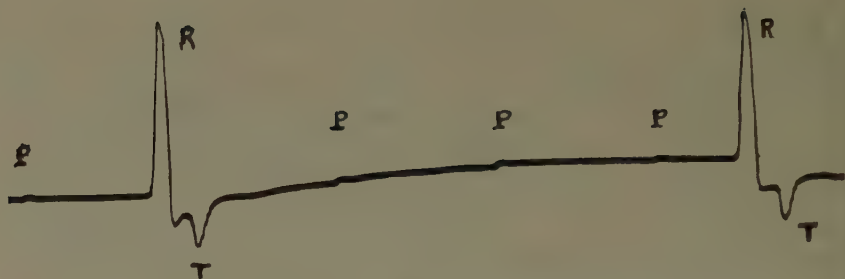
Tracé no 4 - *Mugil auratus* no 20 859: l'onde T s'aplatit -  $t^{\circ}20^{\circ}$ .



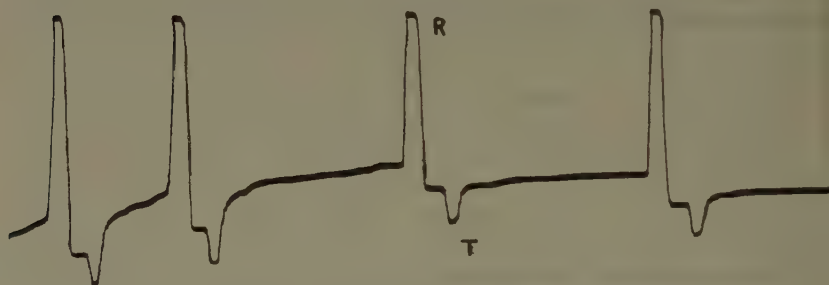
Tracé no 5. - *Mugil auratus* no 20 859: onde T profondément inversée -  $t^{\circ}20^{\circ}$ .



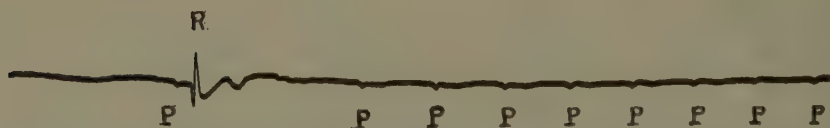
Tracé no 6. - *Mugil capito* no 19 859: arythmie, Q.R.S. élargi - T inversé. -  $t^{\circ}24^{\circ}$ .



Tracé no 7. - *Mugil capito* no 19 859: bloc auriculo-ventriculaire - Q.R.S. et P.R. étalé, élargi - T inversé.  $t^{\circ}24^{\circ}$ .



Tracé no 8. - *Cantharus cantharus* no 21 859: forte arythmie -  $t^{\circ}22^{\circ}$ .



Tracé no 9. - *Cantharus cantharus* no 21 859: Bloc auriculo - ventriculaire -  $t^{\circ}22^{\circ}$ .

Ces anomalies sont en rapport avec des troubles très importants de la fonction osmo-régulatrice du milieu intérieur. La fonction sécrétrice d'ions monovalents par la branchie et d'excrétion par les voies intestinales d'ions bivalents est profondément modifiée. Des altérations électrocardiographiques observées d'origine humorale seraient peut être le reflet de troubles de la kaliémie et de la calcémie notamment.



BLONDEAU (1958) a montré, chez le Lapin que l'anoxie aigüe expérimentale pouvait aussi provoquer des troubles de la repolarisation très nets, dans les dérivations précordiales, qui seraient en rapport avec une hyperkaliémie, troubles du type de ceux que nous signalons.

Au cours du passage "eau de mer - eau douce" chez les sujets étudiés, des altérations dues à l'anoxie pourraient donc s'ajouter à celles provoquées par l'osmo-régulation.

### CONCLUSIONS

La passage brutal de l'eau de mer à l'eau douce déclenche chez *Mugil capito* C. et V., *Mugil auratus* R. et *Cantharus cantharus* C. et V.:

- 1°) une tachycardie précoce suivie d'une bradycardie aboutissant à des anomalies très importantes des accidents électrocardiographiques.
- 2°) un arrêt complet des mouvements operculaires, qui précède toujours un fort collapsus cardiaque aboutissant très rapidement à la mort.

La tachycardie serait d'autant plus importante que le sujet serait plus euryhalin.

Le réflexe de BAINBRIDGE et MAC DOWAL a été suggéré pour expliquer la tachycardie potamotoque et l'anoxie pour comprendre l'apparition de la bradycardie.

Les troubles de l'osmo-régulation auxquels s'ajoute ceux dûs à l'anoxie importante prémortelle ont été soupçonnés d'être à l'origine des anomalies électrocardiographiques.

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# Additions to the Algal Flora of Newfoundland

## Part I: New and Interesting Algae in the Avalon Peninsula and Central Newfoundland

by

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The work of W. R. TAYLOR, 1934/5, on the freshwater algae of Newfoundland, is a standard study upon which the examination of further material from the Island must be based; it is surprising that so few, if any, later published papers have appeared. Our own work is based on four collections, two made by the REV. DR. W. REES-WRIGHT in 1949 and 1950 respectively, and two others made by MRS. A. WHITE, (Buchans), in the summers of 1951 and 1952. DR. REES-WRIGHT's material amounted to more than a hundred tubes, collected from widely-spaced localities in the Avalon Peninsula in the course of studies made under a National Research Council grant. His field notes, including valuable physico-chemical data, help in the consideration of ecological groupings. MRS. WHITE's collections were made in Central Newfoundland around Buchans; they amount to 25 tubes.

The most cursory scrutiny of the results, listed under localities, or under an order of classes, families and species, indicate the wealth of algae, as well as the profusion of the dominant organisms. Well over a thousand taxa have been identified and at the time when the lists were originally compiled we believed that half of them were new records for Canada. In the interval that has elapsed, this number has only been whittled down slightly. We have separated in one section of our findings the taxa that we consider are new to science, the diagnoses being attached. We feel that even more novelties could be discovered in the material, for we have adopted a conservative attitude when discussing individuals that do not fit published descriptions, particularly in those groups where a specialist knowledge has eluded us (e.g. Chrysophyceae, Pyrrophyta, etc.). As all the material had



been fixed before despatch to us, many motile unicells became unidentifiable. There is an unevenness of presentation from group to group, which is inevitable in the circumstances. The desmids, diatoms and blue-green algae are the most abundant members of the communities, and fortunately these groups have been our major interests over a number of years.

We are indebted to the collectors, and to those Canadian and American algologists who have sent us copies of their recent papers. We acknowledge with gratitude the help of MR. R. I. J. TULLY, Science Librarian at the University College of North Wales, who has patiently sought out the obscure journals, within which so much pertinent critical knowledge seems fated to be hidden. Miss M. P. E. STONE has given us invaluable help in the preparation of our illustrations.

#### TOPOGRAPHICAL and ECOLOGICAL DATA

The locality numbers in the systematic sections are devices to shorten the text. Each original sample received an appropriate serial number in the authors' algal collection as it was examined in detail. The Collection, and the diatom slides prepared for the critical identification of members of that group have been housed in the Botany Department of the University College of North Wales, Bangor.

#### AVALON PENINSULA COLLECTIONS:

##### *Locality*

1. S t. J o h n' s. Diatomaceous earth. Mostly species met with today mixed with sponge spicules.

*Pinnularia major*, and *Frustulia* are the most frequent diatoms. 25 species. noted.

2. T a n g l e w o o d. The eastern side of Hogan's Pond, q.v. map co-ordinates 547.245. The following were obtained in April 1949: -

*Collection* 1766, scrapings from stones in shallow water. Mostly diatoms, held among *Calothrix fusca* filaments. 50 organisms noted.

*Colln.* 1766 *b*, seepage under trees; all diatoms in which *Diatoma vulgare* predominates. 13 spp.

*Colln.* 1766 *c*, ornamental pond. 44 spp.

The following were obtained between June and August 1949. *Colln.* 1790, (June) Marsh. 61 species in which *Tabellaria flocculosa* and *Penium cylindrus* were abundant, and the rotifer population

high. Desmids outnumber the diatoms. *Colln.* 1800 (Aug.) Shallow water. Has a remarkable similarity to samples found often in North Wales.

*Tabellaria flocculosa* is the only conspicuous plant among the 81 spp. noted (34 diatom spps.)

*Colln.* 1801 (Aug.) Seepage water in which algae are sparse and rhizopods (e.g. *Trinema linearis*) frequent. The plants noted as abundant in April, e.g. *Diatoma*, absent. 20 spps.

*Colln.* 1803 (Sept.) Stones in Pond, yielding a mixed collection of 68 spps., *Cosmarium subcrenatum* being the most frequent.

*Colln.* 1803 b, ornamental pond, more than half the species are diatoms, but *Cosmarium subcrenatum* is the most frequent organism. 32 spp. in all.

The 1950 collections include: -

*Colln.* 1939, (June) Lily Pond. Minute diatoms in great abundance mixed with sponge spicules, e.g. *Achnanthes minutissima* var. *cryptocephala* and *A. lanceolata* var. *subinflata*. 48 spp. in all, 31 of which are diatoms.

*Colln.* 1939 B, From Sphagnum; rhizopods in large numbers, especially *Quadrula symmetrica* and *Corythion dubium*, desmids absent and the diatoms very few. 25 spp. noted.

*Colln.* 1943. From Sphagnum. Rhizopods again numerous, particularly *Corythion*, but diatoms remain in abundance, e.g. *Tabellaria* spp., *Eunotia curvata* and *Pinnularia viridis* var. *sudetica*. 48 spp. in all.

*Colln.* 1964, (June), from moist mud. Has a high diatom population mainly of filamentous *Eunotia* spp. Some of these were teratological. 46 spp.

*Colln.* 2012, from marsh at pH 5.9. Diatoms both very numerous and well-developed (*Melosira* spp., *Frustulia* spp., *Eunotia curvata* and *Pinnularia viridis* all abundant.) The desmids, though plentiful as specimens were mostly in a moribund or empty condition. 74 spp.

#### *Locality.*

3. H o g a n' s p o n d. Most samples, other than those accounted for above, were gathered at 553 254. The 1949 material was obtained in June: -

*Colln.* 1788. North Pool. A rich sample in which the desmids about equal the diatoms, and other Chlorophyta are above the average frequency. The main filamentous species is *Hyalotheca dissiliens*, which was in conjugation. *Tabellaria flocculosa* is very abundant. 70 spp.

*Colln.* 1788 B. Sphagnum collection. About half the species are common to the Pool but in different proportions, e.g. the blue-greens are more prominent. Rhizopods are abundant. *Pinnularia* spp. are prominent. 73 spp.

Colln. 1789. Shore Pool. Mostly *Tetraspora* colonies with short lengths of filamentous spp. 35 spp. in all.

Colln. 1789 B. Marsh with Sphagnum. Richer than the last, but with some similarity, 14 spp. being common to them. Rhizopods are more conspicuous. *Pinnularia viridis* is in marked abundance. 64 spp.

Colln. 1805, taken in Sept. 1949 at 1.5 M. deep. Mostly diatoms, *Frustulia* being abundant. 61 spp.

The 1950 samples were taken in June:

Colln. 1996. Scrapings off stones, yielding *Dichothrix Baueriana* and other blue-green algae. 46 spp.

Colln. 2001. By N. Jetty. A big haul of diatoms (73) especially *Frustulia*. This sample showed much conifer pollen. 114 spp. in all.

Colln. 2010. Mud from bed of Isoetes; diatoms account for all except 10 of the total species identified. *Pinnularia viridis*, *Tabellaria fenestrata*, *Cymbella ventricosa* and *Surirella* are the most prominent forms. 76 spp.

4. C a r p a s i a n R d., S t. J o h n ' s. August 1949. Five small hauls from a stream, some from rapidly flowing water, and the rest from slow flowing or stagnant water. *Spirogyra*, *Vaucheria* and *Microspora pachyderma* are the main filaments: *Synedra amphicephala* is abundant among them. 33 spp.

5. L o g y B a y. October. Two small collections from rocks in the spray of sea water. *Calothrix pulvinata* is the only notable species. 11 spp.

6. H o l y r o o d, including North Arm River. From this group we have identified 45 species and varieties of the diatom genus *Eunotia*, together with a large representation of *Neidium* and *Anomooneis*.

Colln. 1928 (Aug. 1950). A mixture of *Zygnema* and *Mougeotia* with a few associates among the diatoms (*Synedra ulna*) and desmids. 34 spp. in all.

Colln. 1959. (Aug. 1950). *Oedogonium* in profusion with many desmids, *Closterium parvulum* being frequent. 68 spp.

Colln. 1969 (Aug. 1950). *Oedogonium* abundant, with many desmids, *Closterium parvulum* with zygotes. 38 spp.

Colln. 1930 (July 1950). *Oedogonium* abundant with a large population of both desmids and diatoms. 10 spp. of *Closterium* observed, *C. parvulum* and *C. navicula* being the principal. 99 spp. identified.

Colln. 1949. (Aug. 1950), from shallow water of pond. A collection of forms, no one being dominant. Over half are desmids (71). 132 spp. in all.

7. S e a l C o v e. Two sets of localities are listed together here, 1931 and 1951 being close to one another, whilst 1929 and 1998 were taken higher up the valley. (N.B. Locality 16 is in this area). These



seem to be the richest gatherings in the Rees-Wright collections, especially in *Eunotia* (45 forms), *Neidium* and *Anomoeoneis* alliances.

Colln. 1929. Marshy pool, extremely rich in diatoms, 122 forms having been determined, *Eunotia* being prominent as a genus, with *Frustulia rhomboides*, *Tabellaria fenestrata* and *Stauroneis phoenicenteron*. 152 spp. in all.

Colln. 1931. On rocks. This gathering includes many plankton forms especially small desmids and several unusual green algae. *Oedogonium* is the only frequent organism. 94 spp.

Colln. 1951. Stream at pH 6.9. *Mougeotia* and *Oedogonium* are the main filaments, harbouring numerous small diatoms and *Tabellaria flocculosa*. 113 spp.

Colln. 1986. Marsh pool with abundant sponge spicules and a rich variety of algae, largely desmid in character (56 spp.) *Stigonema panniforme* and *Tabellaria fenestrata* are the most prominent organisms. 127 spp. in all.

Colln. 1998. Marsh pool, more than half the species being diatoms. *Eunotia* prominent with *Closterium* spp. 164 spp. identified.

8. These collections are now combined with locality 6, q.v.

9. Bauline. Four groups of stations are listed under this general heading; all are rich in rhizopods.

Colln. 1940. Sphagnum, June. Mainly rhizopods (12 spp.) among which *Hyalosphenia papilio*, *Arcella vulgaris* and *Amphitrema flavum* are the most frequent. 27 spp. in all.

Colln. 1954, muddy trickle. Mixed collection mainly of desmids and diatoms, *Melosira distans*, *Tabellaria fenestrata* and *Pinnularia viridis* are the most frequent. 68 spp. listed.

Colln. 1956. Bog pool, with no outstanding species. 32 spp.

Colln. 1982. Tussock of Sphagnum containing *Kentrosphaera* and the rhizopod *Assulina muscorum* only. 2 spp.

Colln. 1980. contains a high proportion of *Closterium* spp. and individuals, particularly *C. striolatum* and *C. parvulum*. *Tabellaria flocculosa* is also frequent. 111 spp. noted.

Colln. 1973 Small pool with *Hyalotheca dissiliens* abundant, *Closterium ulna* and *Stauroneis anceps* frequent. 43 spp.

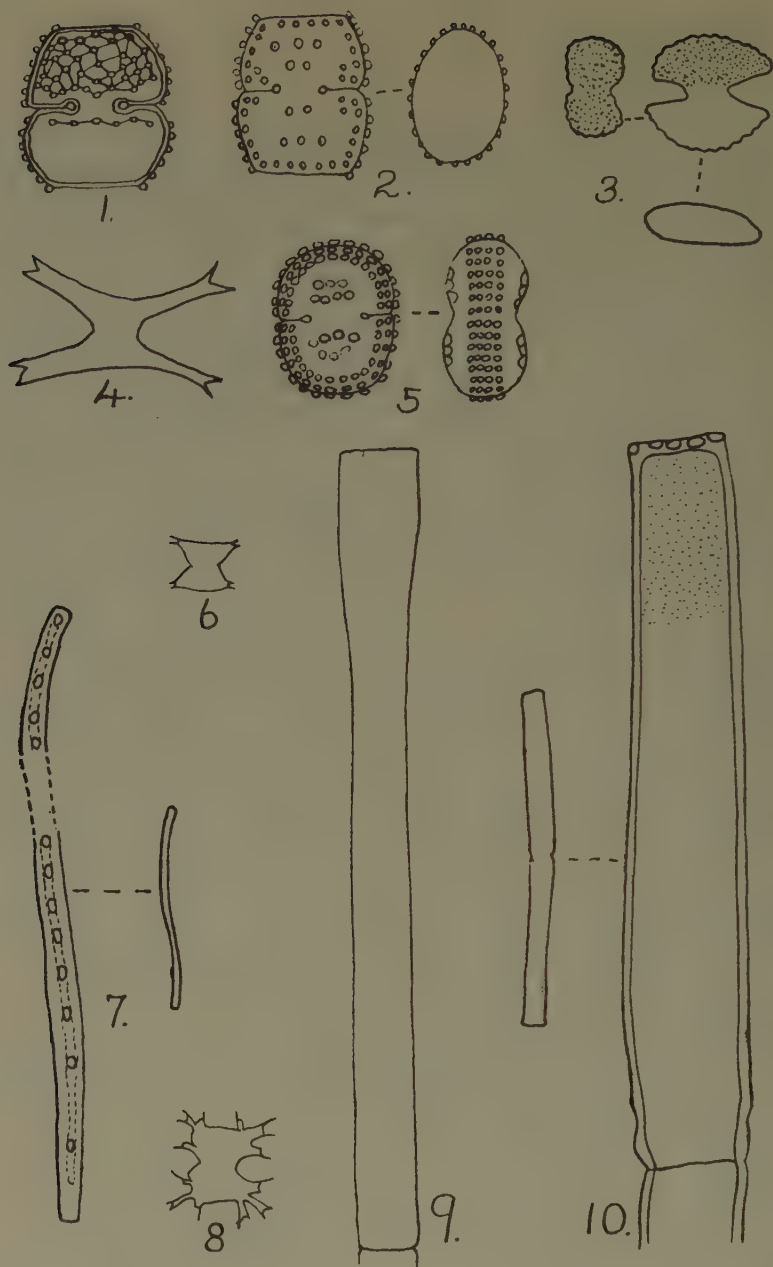
9a. Colln. 1970 pond, with very few organisms, only 10 spp.

Colln. 1999 pond at pH 8.30. A rich collection containing many unusual algae for America. Desmids (63) account for about a third of the total. *Thiophysa macrophysa* abundant. 191 spp.

9b. Colln. 1933 River. Very few organisms. 3 spp. only.

Colln. 1978 River. *Stigonema mammosum* chiefly. 34 spp.

Colln. 1995 River. A thick tangle of *Spirogyra* harbouring a mixture with no other dominant plant. Two tubes contained 56 spp. in all.



# Plate I

1 *Cosmarium cosmetum* W. & G. S. WEST. (scale B). 2 *Cosmarium margaritifera* v. *quinquepunctatum* var. nov. (scale B). 3 *Cosmarium pseudotitophorum* sp. nov. (scale B). 4 *Staurastrum brachiatum* v. *Notarisii* Rabh. (scale B). 5 *Cosmarium quadrifarium* v. *Taylorii* var. nov. (scale B). 6 *Staurastrum granulosum* f. *minutissimum* f. nov. (scale B). 7 *Closterium toxon* f. *sigmoideum* Ir.-Mar. (scale A). 8 *Staurastrum quadricornutum* v. *heterospinum* var. nov. (scale B). 9 *Pleurotaenium trabecula* f. *palum* f. nov. (scale B). 10 *Pleurotaenium eugeneum* v. *simplicius* var. nov. (left figure sketched, right figure scale B).

9c. Colln. 1968. Stagnant peat pool at pH 5.3. A small number of species, *Chlorogonium elongatum* frequent. 17 spp.

Colln. 2007. Small pool in which desmids are more abundant than diatoms; *Closterium striolatum* abundant and *Euastrum ansatum* frequent. *Pinnularia viridis* is the most prominent diatom. 56 spp. noted.

10. Salmonier Line. Collections arranged in two sets, the first (10) being at the northern end nearer Holyrood, while the second set (10a) is near Father Duffy's Well, locality 20 q.v.

Colln. 1983, stream, June. Diatoms in abundance (75) including *Diatoma tenue*, *Meridion circulare* var. *constricta* and *Gomphonema parvulum* in great numbers. 95 spp. noted.

Colln. 1991, marsh pool, June. A smaller collection in which *Hyalotheca dissiliens* is frequent, with its zygotes; *Tabellaria flocculosa* is present in large numbers of short filaments. 38 spp. noted.

10a. Colln. 1934, Small pool with abundant Iron Bacteria, July.

*Closterium* spp. prominent. 37 spp. in all.

Colln. 1936. A water-lily pond drying out in July. Many of the algae dying, many macerated ideoblasts scattered among them. Diatoms restricted to two species but a good desmid flora. *Pleurotaenium trabecula* and *Xanthidium armatum* frequent. 51 spp. noted.

Colln. 1961, Sphagnum collection in July, mainly of diatoms (75) with *Pinnularia viridis* var. *sudetica* frequent. Many sterile filaments of *Anabaena*; a rhizopod, *Corythion dubium* is also frequent. Most species are moribund. 102 spp. noted.

11. Briggs Barrens. August material.

Colln. 1938. Pond, a rich collection with many sponge spicules, filaments of *Zygnema*. *Oscillatoria tenuis* and *Anabaena echinospora* var. *microspora* are abundant, with numerous diatoms (74). 111 spp. noted.

Colln. 1948, marsh on edge of Pond Barrens (original locality no. 28). Rich collection mainly made up of diatoms (109). *Frustulia rhomboides* var. *crassinervia* is the most abundant organism, but the material is rich in forms of *Eunotia*, *Fragilaria* and *Pinnularia*. 166 spp. in all.

12. Manuels River. All samples from the lower part of the river basin, and in parallel with the Seal Cove collections.

Colln. 1944. Stagnant pool in July. A mixture of brackish and fresh-water material, very rich in diatoms (101), among which *Amphiprora ornata*, *Amp. paludosa* and *Nitzschia ignorata* are abundant; *Nitzschia* and *Surirella* are the most prominent genera. *Ulothrix variabilis* is occasional, but conjugate algae are represented by 2 forms only. 111 spp. recognised.

Colln. 1950, bed of flowing river, July. An even balance between



desmids and diatoms. *Spirogyra* and *Sphaerosoma granulatum* prominent filamentous types, with *Synedra acus* and *Synedra ulna* frequent diatoms, an unusual association in the Rees-Wright collections. 82 spp. in all.

Colln. 1952, rapid water, July. Somewhat similar, with an abundance of filaments, *Spirogyra*, *Mougeotia* and *Zygnema* all noteworthy, with sterile *Oedogonium* and *Spondylosium planum* a little less frequent. *Closterium parvulum* is the most outstanding desmid. *Synedra ulna* is abundant. 46 spp.

Colln. 1956, from cow-prints on bank, July. Diatoms only, *Pinnularia* spp. most numerous with *Nitzschia ignorata* and *Frustulia vulgaris* frequent. 41 spp. found.

Colln. 1962, floating material from stagnant pool, July, including *Ulothrix variabilis* and *Frustulia rhomboides* var. *crassinervia* as the most abundant forms. Only one conjugate alga, but diatoms are in large numbers (78), including several brackish water forms, e.g. *Nitzschia* spp. 85 spp. in all.

Colln. 1988, at head of tide. Mainly diatoms (49), some brackish, but none in noteworthy abundance. 55 spp. in all.

13. Indian Meal. (map co-ordinates 582 335) thus in the Bauline zone. All samples taken in July.

Colln. 1945, pool with pH 6.8. Desmids (40) prominent, but *Eremosphaera viridis*, *Pinnularia viridis*, *Frustulia rhomboides* and varieties, *Chroococcus turgidus* with *Eunotia* spps. are the outstanding plants. 119 spp. identified.

Colln. 1971, Sphagnum tussock, pH 6.1. Many rotifers and rhizopods. *Pinnularia viridis* var. *sudetica* abundant; the Euglenophyta are noteworthy. 26 spp. only.

Colln. 1990, peat cutting, with very few organisms, 15 spp. only.

14. Colinetto Placentia Line, including two groups, 14 a and b. 14 a being roughly midway, and 14 b in the neighbourhood of The Cataract. (original locality number 8).

14a. Colln. 1947, acid pool at pH 6.2, August. Many sponge spicules. 56 spp. identified.

Colln. 2008 above fall, *Spirogyra* filaments mainly. 10 spp. in all.

15. Bay Bulls. Large lakes in the east of the Peninsula, close to aera 17, Original Locality 26 now included here (sample 1941)

Colln. 1941, North Pond; roadside ditch in peat moss, yielding a reddish-brown flocculent mass due to *Leptothrix ochracea*. June sample. Filaments include *Oedogonium* and *Tribonema minus*. *Pinnularia viridis* is abundant, with *Tabellaria flocculosa* and *Closterium striolatum* frequent. 51 spp. identified.

Colln. 1953, Lower Pond marsh in June. No outstanding species but several diatoms occur freely, e.g. *Eunotia* species and *Cymbella*

*naviculiformis*; diatom forms are numerous (90). The association of *Actinella punctata* with *Tabellaria binodis* is noticeable here (QUEN-  
NERSTEDT, 1949). 116 spp. found.

Colln. 1966, Marsh on hill top, east of Lower Pond, June. Mainly diatoms (46), *Tabellaria flocculosa* and *Asterionella formosa* var. *Ralfsii* are abundant, as well as the blue-green, *Chroococcus minutus*. 77 spp. found.

Colln. 1975, Sphagnum squeeze, Lower Pond, July, holding much conifer pollen and very numerous rhizopods (11 spp. observed). *Pinnularia viridis* alone abundant. 27 spp. discovered.

Colln. 1981, Lower Pond stream. Fairly rich mixture, *Mougeotia* and *Oscillatoria tenuis* var. *tergestina* abundant filaments, with the two *Tabellaria* spp. frequent. 87 spp. in all.

Colln. 2014, Big Pond marshland during period of ice-melt in April. Desmids flourishing, especially *Tetmemorus granulatus* and *Micrasterias truncata*; diatoms include a number of *Neidium* forms in abundance, 68 spp. of diatoms being identified. 90 spp. in all.

Colln. 2015, As above; much sand mixed with sponge spicules along with a few diatoms. 25 spp. noted.

16 G u l l P o n d in the Seal Cove Valley. (Other lakes bear this name e.g. on the Witless Bay Line, 18b).

Colln. 1955. A black silt from seepage in a marsh below the Pond, August. Rich in desmids (45), many of which are in separate semicells though containing their protoplasts and chromatophores. *Pleurotaenium minutum* and *Tabellaria flocculosa* abundant; *Closterium setaceum* and *Gymnozyga moniliformis* frequent. 77 spp. in all.

Colln. 1997, Dam and seepage. Much evidence of the activity of Iron-bacteria. *Oscillatoria tenuis* var. *natans* frequent. Only 7 spp. identified.

17. T o m W a l d r o n ' s P o n d. Samples obtained in August.

Colln. 1958, brook near road-bridge at pH 6.3. A small gathering with *Tabellaria flocculosa* abundant. 44 spp. in all.

Colln. 2000, A sample carrying many representatives of the lake plankton, particularly rich in *Conjugatae* (74) and *Myxophyceae*. Sponge spicules very abundant. *Euastrum* spp. abundant, with *Oedogonium* sterile filaments and *Bulbochaete insignis* frequent. Also prominent are *Closterium acutum* var. *linea*, *Gloeotheca linearis* and *Tabellaria fenestrata*. Diatom species are relatively few among the total of 147.

Colln. 2004. two samples from Pond outlet, mostly desmids (47), with *Gymnozyga moniliformis* and *Closterium acutum* var. *linea* frequent. There is also an abundance of *Zygnema* filaments in a moribund condition. 73 spp. in all.

Colln. 2006, Lower Pond, with abundant sponge spicules. Diatoms

prominent (75) among which *Melosira* spps. and *Eunotia* spp. are both very abundant, *Neidium* spps. abundant and *Frustulia rhomboides* frequent. 96 spp. identified.

Colln. 2017, outflow of Pond in June at pH 8.9; DR. REES-WRIGHT observes *in litt.* that „the pH value may seem odd but the stream was even more alkaline higher up, at pH 9.5.” He suggests that potash had leached out from an extensive area that had been burnt out. A rich mixed collection in which *Tabellaria fenestrata* and *Hapalosiphon intricatus* are frequent, and in which several planktonic forms are present. 80 spp. noted.

18. W i t l e s s B a y L i n e. 18 *a* at the western end, about 3 miles from Holyrood, 18 *b*, a Gull Pond, about 5 miles from the eastern end. Collections 23 and 29 are also associated with this Line.

18*a*. Colln. 1960, slow stagnant stream at pH 6.0, August. Largely diatoms (84) with an abundance of *Eunotia* spp. 126 spp. in all.

Colln. 1994, as above pH 6.0. Diatoms again conspicuous (50) as a class, *Frustulia* and *Tabellaria* both frequent, with *Closterium ulna* and *Cl. striolatum* frequent desmids. 87 spp. noted.

18 *b*. Colln. 1979, Gull Pond at pH 6.80, very sandy and with no outstanding organisms. 42 spp. observed.

19. W i n d s o r L a k e, general map co-ordinates 570 245.

Colln. 1942, Thorburn Rd., a stream at pH 6.8, June. *Closterium* very prominent, especially *C. striolatum*, with *Tabellaria* spp. and *Eunotia curvata* abundant diatoms. Smaller species of *Eunotia* are also very abundant, the diatoms accounting for 57 species, and the desmids for 44 species in a rich gathering, 124 spp. in all.

Colln. 1963, roadside stream at pH 6.8, July. Comparable to the last (32 desmids, 59 diatoms) but with *Ulothrix variabilis*, *Frustulia rhomboides* and *Stauroneis phoenicenteron* frequent. 110 spp. observed.

20. F a t h e r D u f f y ' s W e l l, (Salmonier Line), midway between Holyrood and Salmonier. June gatherings.

Colln. 1972, Sphagnum squeeze from near a pond, at pH 5.2. *Pinnularia viridis* var. *sudetica* the only frequent alga among numerous rhizopods, *Hyalosphenia elegans* being frequent. 16 spp. only.

Colln. 2013, relict pond at pH 6.1. Sterile *Oedogonium* filaments numerous with both main *Tabellaria* species, *Eunotia curvata* and *Closterium striolatum* frequent. Desmids outnumber the diatoms. 82 spp. in all.

21. C a p e S t. F r a n c i s, June gatherings.

Colln. 1974, running water. A small collection in which filamentous diatoms are abundant, especially *Tabellaria flocculosa* and *Diatoma tenue* with *Tabellaria fenestrata* among sterile *Mougeotia* filaments. 44 spp. noted.



Colln. 1984, Pouch Cove, aqueduct ditch. A small collection in which *Tabellaria flocculosa* is prolific, with *Microspora floccosa*. *Ulothrix variabilis* and *Eunotia curvata*. 19 spp. only.

22. P a r a d i s e, map co-ordinates 535 205.

Colln. 1977, with Sphagnum and sponge spicules, June. The only place with *Draparnaldia glomerata*, its mucilage crammed with minute diatoms (71). *Melosira* spp., *Eunotia lunaris* and *Pinnularia viridis* are the more abundant types. 93 spp. noted

23. "H u d d l e", Witless Bay Line, a fishing shack, midway between Witless Bay and Holyrood. August collections.

Colln. 1946, running water. *Netrium oblongum* var. *cylicum*, *Cylindrosystis Brebissonii* and *Pinnularia viridis* var. *sudetica* all abundant and *Tetmemorus granulatus* frequent. 51 spp.

Colln. 1987, moorland pool in peat, with pH 7.6. The richest haul of desmids in the present series, 93 noted, mainly *Cosmarium* and *Euastrum* species. Among the few diatoms, *Frustulia rhomboides* is abundant. 138 spp. identified.

Colln. 1989, running water. Three species of *Mougeotia*, all unidentifiable, with *Hyalotheca dissiliens* abundant, and *Netrium oblongum* var. *cylicum* frequent. Only 19 spp.

Colln. 2009, backwater at pH 5.3. A small number of species but their individuals present in large numbers. *Tabellaria flocculosa* abundant, *Tabellaria fenestrata* frequent; *Hyalotheca dissiliens*, *Mesotaenium endlicherianum* var. *grande*, *Chroococcus minutus*, and *Sphaerocystis Schroeteri* frequent. 49 spp. identified.

24. H o d g e w a t e r. September collections.

Colln. 1992, pond, at pH 7.36. *Zygogonium ericetorum* abundant with *Tolypothrix tenuis* and *Tabellaria fenestrata* frequent. 55 spp. identified.

Colln. 2003, pond. A tangle of *Zygnema*, *Spirogyra* and *Hormidium subtile*, with *Tabellaria fenestrata* frequent in a mixed collection of 88 species.

25. G u l l I s l a n d, off East coast at Witless Bay. April collections.

Colln. 2016, running water. Mainly diatoms (46) with *Fragilaria virescens* and *Diatoma vulgare* abundant. *Pinnularia major* is frequent, along with *Chlamydomonas Ehrenbergii*. 59 spp.

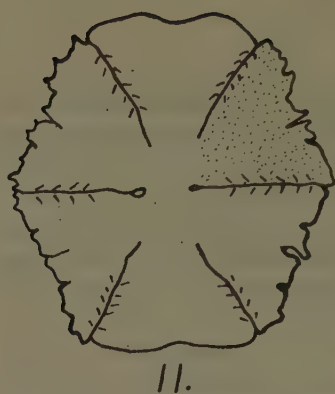
Colln. 2016 B, from rocky pool at 50 ft. Only 10 species.

26. C o n c e p t i o n H a r b o u r, August, yielded only two diatoms from the Fucus zone. (Colln. 1993).

27 and 28 have been discarded as locality numbers.

29. W i t l e s s B a y L i n e, Five Mile Pond.

Colln. 1937, spillway at pH 6.3, August. Desmids (35) in larger numbers than the diatoms, *Closterium* spp. being quite prominent,

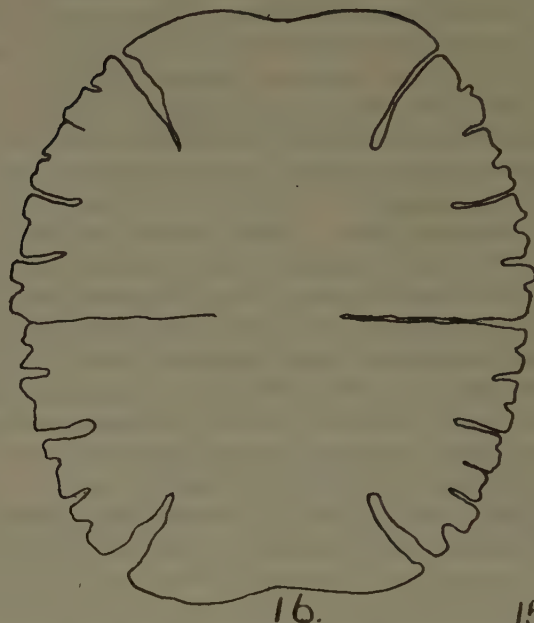


11.



12.

B  
20μ  
Scales  
A  
20μ



16.



13.



14.

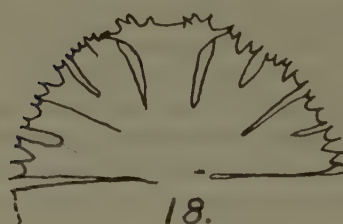
50μ



15.



17.



18.



19.

# Plate II

11 *Micrasterias tetraptera* v. *angulosa* f. *avalonensis* f. nov. (scale A). 12 *Micrasterias crux-melitensis* [ (EHR.) HASS.] RALFS. (scale A). 13 *Cosmarium cucurbita* f. *latior* W. & G. S. WEST (scale A). 14 *Netrium digitus* f. *ellipticum* f. nov. (own scale) 15 *Cosmarium pachydermum* f. *minus* Nordst. 16 *Micrasterias jenneri* v. *lata* var. nov. (scale A). 17. *Euastrum attenuatum* WOLLE (scale B). 18 *Micrasterias conferta* v. *hamata* WOLLE forma (scale A). 19 *Euastrum verrucosum* v. *ornatum* var. nov. (scale B).

especially *C. subulatum*. *Staurostrum punctulatum* is frequent; among the few diatoms, *Tabellaria* spp. are abundant. 56 spp. observed.

*Colln.* 2011, west pool, above dam, at pH 6.1, September. Very rich in diatoms (91) but no outstanding species. 123 in all.

#### CENTRAL NEWFOUNDLAND collections.

##### Buchans.

1. slime from stream bed. W. & T. 2121, 10; 6; 51.

8 species only, *Synedra amphicephala* va. *Tetraspora gelatinosa* a.

11. River, from weeds growing on rocks, W. & T. 2115, 3.8.51.

12. 37 spp., mainly diatoms. *Frustulia crassinervia* va.

12. River, slime off stones under such weeds. W. & T. 3.8.51. 111 spp., a mixture of planktonic forms, especially among the desmids, and epiphytic algae. No rhizopods listed. *Synedra amphicephala* a; *Synedra acus* a; *Tabellaria fenestrata* f; *Tabellaria flocculosa* f.

13. River, bog. W. & T. 2128. 3.8.51.

54 Spp. *Frustulia crassinervia* a; *Navicula subtilissima* f.

14. River, sediments W. & T. 2129. 3.8.51.

23 spp. and 5 spp. of rhizopods which are frequent, especially *Trinema lineare*.

17. St. Georges Road, lake sediment. W. & T. 15.9.51. 136 spp. the diatoms being the bulk of the material. Many desmids are represented, but only by isolated or even a solitary specimen. The same scarcity of individual members of a species is seen for most *Cymbella* and *Pinnularia* species. Among the blue-greens *Gloeocapsa* is well represented.

*Tabellaria fenestrata* f; *Cymbella ventricosa* f. *Anomoeoneis brachysira* f. *thermalis* f. *Denticula tenuis* v. *crassula* f.

20. North Buchans, river backwater, W. & T. 2208, 1.6.52. 80 spp., mainly diatoms, also 6 spp. rhizopods. *Frustulia rhomboides* a; *F. crassinervia* a.

Stream from melting snow W. & T. 2209, 24.5.52. *Ulothrix variabilis* filaments only.

21. slime from submerged stone, from stream, Rothermere Road. W. & T. 2210. 25.5.52. 61 spp. *Diatoma tenuis* va.

24. Rothermere Road, bog, W. & T. 2213., 25.5.52. 2 diatoms only in one sample. 39 spp. in a second sample. *Anomoeoneis exilis* f. *Pinnularia Brebissonii* f. *P. microstaruon* f. *Achnanthes minutissima* v. *cryptocephala* f.



25. stream from melting snow, W. & T. 2214, 25.5.52. 4 spp. only, none frequent. There were no algae in three other snow-melt samples.

#### Buchans "Mud Hole".

22. slime from submerged stone, W. & T. 2211, 24.5.52. 31 spp. *Tabellaria flocculosa* va; *Stigeoclonium lubricum* va

23. bog. W. & T. 2212, 24.5.52. 52 spp. and also 4 spp. rhizopods. *Pinnularia viridis* v. *sudetica* a; *Staurostrum Meriani* f; *Rhopalodia gibba* v. *ventricosa* f.

24. river towards swimming pool, W. & T. 2215, 6.6.52. 51 spp. *Tabellaria flocculosa* a.

#### Sandy Lake.

2. bog along the road to the lake W. & T. 2120. 12.6.51. 31 spp., mostly diatoms. *Frustulia crassinervia* a. *Frustulia rhomboides* f.

3. as above, W. & T. 2114, 12.6.51. 22 spp., among *Mougeotia* filaments are *Chlamydomonas* spp. a; *Frustulia crassinervia* va *Pinnularia sudetica* a.

4. as above, W. & T. 2112, 12.6.51. 47 spp., mainly diatoms, including *Gomphocymbella*, *Amphicampa hemicyclus* a, *Eunotia triodon* f.

5. as above. W. & T. 2124, 12.6.51. 32 spp., among which the genus *Eunotia* is conspicuous. *Pinnularia sudetica* va. *Eunotia curvata* f, *E. lapponica*, *Frustulia crassinervia* f.

6. lake sediment, W. & T. 2116, 12.6.51. 15 spp., with 10 spp. thizopods, much alder and conifer pollens.

#### Red Indian Lake.

7. stagnant pool in a stream drying out. W. & T. 15.7.51. 95 spp., mainly diatoms, especially the genus *Eunotia*, *Pinnularia mesolepta* f. *Eunotia curvata* f.

8. stream entering lake. W. & T. 16.7.51. 33 spp. with iron-bacteria in filaments (va.). A desmid population with some diatoms.

9. silts of the stream. W. & T. 19.7.51. 13 spp. mainly diatoms.

10. stagnant pool. W. & T. 19.7.51. 129 spp. mostly naviculoid diatoms and *Eunotia* spp. *Eunotia praemonos* a. *Tabellaria fenestrata* f. *Tabellaria flocculosa* f. *Frustulia crassinervia* f. A few rhizopod spp. observed.

18. stream between lake and Buchans. W. & T. 2127. 7.10.51. 68 spp. *Tribonema affine* a, *Tribonema minus* a. *Tabellaria flocculosa* a, *Synedra emphycephala* a. *Scenedesmus alternans* f.

#### Corner Brook.

15. river, one mile from village. W. & T. 2126. 15.9.51. 22 spp.

*Oedogonium* sterile filaments va *Ankistrodesmus falcatus* v. *mirabilis* a, *Aphanochaete repens* f. *Closterium moniliferum* f. There were no diatoms in this tube.

16. bog silts on the road to St. Georges. W. & T. 2125. 15.9.51. 26 spp. none common.

#### Millertown.

19. stream silts. W. & T. 2207. 3.6.52. 65 spp. all diatoms among *Ulothrin* filaments, *Meridion circulare* a.

### NEW TAXA OF ALGAE

*Netrium digitus* (Ehr.) Itzigs. and Rothe in Rabh. 1856.

*forma ellipticum*. forma nova nobis.

A v a l. Colinet Line (14a) in acidic pool.

Elliptical without median constriction, not produced, but evenly rounded at the ends. Intermediate in its proportions between var. *intermedium* and the type variety, even longer, 362—420  $\mu$  long, 66—72  $\mu$  wide. Fig. 14.

forma cellulis ellipticis nec in medio constrictis nec productis, apicibus aequaliter rotundatis; in rationibus inter var. *intermedium* et typicum sed longioribus, 362—420  $\mu$  long., 68—72  $\mu$  lat.

The medley of genders is forced by the provisions of the International Code.

*Closterium subulatum* (Ktz.) Breb. 1856. var. *sigmoideum* var. nova nobis.

A v a l. Bauline, among *Sphagnum*.

Dimensions as in the type, *C. subulatum* var. *subulatum*, but the cells sigmoid.

Mensurae sunt typi, sed forma sigmoidea.

The type is found freely in the Avalon Peninsula and its zygospores were seen in Bauline material.

*Pleurotaenium coronatum* (Bréb. ex Ralfs) Rabh. 1865.

var. *robustum* W. West 1892, forma *erectum* forma nova nobis.

A v a l. Witless Bay line (23). Plants about  $8\frac{1}{2}$  times longer than broad (so that they fall within the varietal range), 578  $\mu$  long, 68  $\mu$  wide at the base, 48  $\mu$  wide at the apex. Basal inflation shallow, the rest of the wall straight. Fig. 10a.

Cellulis diametro circiter  $8\frac{1}{2}$  -plo longioribus quam latoribus, inflatione basali tenui, lateribus superioribus rectis, 578  $\mu$  long., 68  $\mu$  lat. bas., 48  $\mu$  lat. ap.

*Pl. eugeneum* (Turn.) W. & G. S. West. 1904. var. *simplicius* var. nova nobis,

A v a l. Bauline; Colinet Line (14a); Witless Bay Line (18a). Margins of the semicell not undulate, and with only the faintest indication of a basal swelling, the greatest width being slightly above the semicell base. Longer in its proportions than *Pl. coronatum*, 534—677  $\mu$  long, 35—40  $\mu$  maximum width, about 34  $\mu$  wide at the base and 29—38  $\mu$  across at the apex. Walls with numerous mucilage pores. (Fig. 10)

Semicellulis non undulatis et latitudine maxima paullulum supra basin semicellularum: in proportione longius quam *Pl. coronatum*, 534—677  $\mu$  long., 35—40  $\mu$  lat. max., circa 34  $\mu$  lat. bas., 29—38  $\mu$  lat. ap. Membrana poris mucilaginis multis praedita.

We have not traced any other forms of the species in the Newfoundland material.

*Pl. trabecula*. (Ehr.) Næg 1849. forma *palum* forma nova nobis.

A v a l. Salmonier Line. A curious form with a long spade-like swelling at the apices immediately beyond a gradual tapering from the base; about 600  $\mu$  long, 24  $\mu$  wide at the base, 36  $\mu$  wide at the apex, the enlargement starting 50  $\mu$  from the end. (Fig. 9).

Forma inflatione 50  $\mu$  ex apice simili palae incipit, lateribus gradatim attenuatis super basin semicellularum. Circa 600  $\mu$  long., 24  $\mu$  lat. bas., 36  $\mu$  lat. ap.

This species is well represented in Dr. Rees-Wright's collections, but few specimens occur in the Central Newfoundland material.

*Euastrum verrucosum*. (Ehr. 1835). Ralfs. 1848. var. *ornatum* var. nov. nobis.

A v a l. Seal Cove. Upper angles of the lateral lobe furnished with 2—3 distinct small sharp teeth. Length 68  $\mu$ , breadth 61  $\mu$ , polar lobe 30  $\mu$  wide. (Fig. 19).

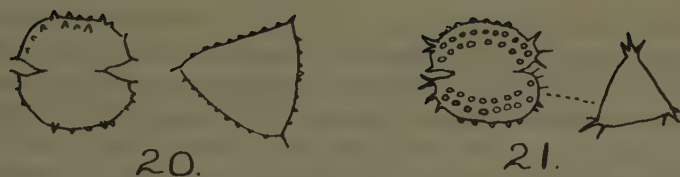
Angulis superioribus loborum lateralium dentibus 2—3 acutis et parvis praeditum. 68  $\mu$  long, 61  $\mu$  lat., 30  $\mu$  lat. pol.

The type, *v. verrucosum*, also occurs at Seal Cove.

### *Cosmarium*

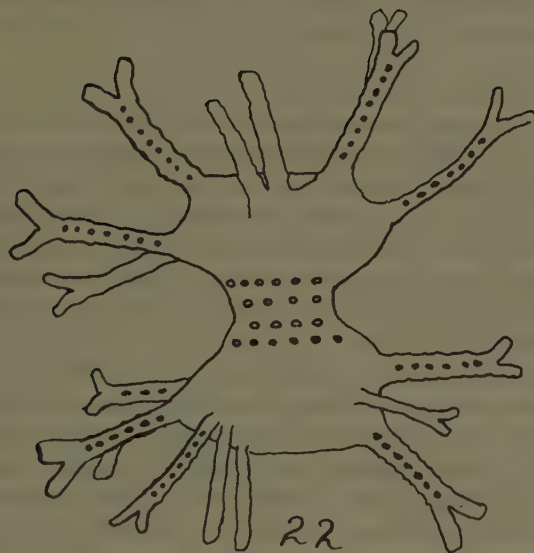
*C. avalonense* sp. nova nobis,

A v a l. Brigus Barrens. Large, pyramidate, deeply constricted, the sinus linear and rounded within. Basal angles rounded, the sides and apex evenly convex. Cell wall granulate throughout, the granules very small and acute, evenly distributed. Lateral view of semicell elliptical. Length 115—118  $\mu$ , breadth 79—82  $\mu$ , isthmus 22—26  $\mu$  wide. (Fig. 23).

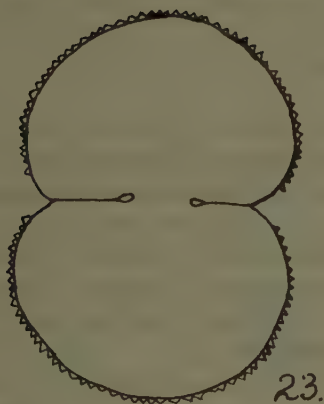


20.

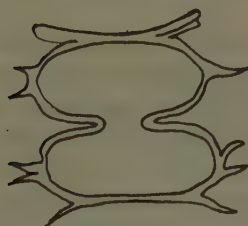
21.



22



23.



24.

### Plate III

20. *Staurastrum cruciatum* v. *Wrightianum* var. nov. (scale B) 21 *Staurastrum avalonense* sp. nov. (scale B). 22 *Staurastrum arctiscon* v. *truncatum* Ir.-Mar. (scale A). 23 *Cosmarium avalonense* sp. nov. (scale A). 24 *Xanthidium armatum* v. *irregularius* W. WEST (scale B).



*Cosmarium* magnum, profunde constrictum, sinu lineari introrsum rotundato; semicellulis a fronte visis pyramidatis angulis inferioribus rotundatis, lateribus et apicibus convexis: membrana omnia granulis acutis eit minutissimis ornata; a latere visae semicellulae ellipticae. Long. 115—118  $\mu$ , lat. 79—82  $\mu$ , isth. 22—26  $\mu$ .

This handsome species should be compared with *C. dentatum* Wolle, from which it differs in its denser granulation, particularly as it is distributed over the apex.

*C. buchansianum* sp. nova nobis.

C e n t. stream between Buchans and Red Indian Lake (18). Small, a little longer than broad, the median constriction deep and the sinus narrowly linear. Semicells truncate-semicircular, the basal angles sub-rectangular or somewhat rounded, lateral margins with 3 crenae, apex widely truncate with 3—4 distinct crenae. Membrane with 3 horizontal rows of granules, ca. 4 or 5 visible in each row in front view. Side view of semicell circular. Length 25.4  $\mu$ , width 21.2  $\mu$ , isthmus 6  $\mu$ . (Fig. 80).

*Cosmarium* parvum paullo longius quam latum constrictione profunde sinu anguste lineari; semicellulis truncatis semicircularibus angulis inferioribus sub-rectangularibus vel paene rotundatis, lateribus tricrenatis, apicibus late truncatis cum 3—4 crenis distinctis; membrana seriebus 3 horizontalibus granulorum, a fronte visis circa 4-5, instructis. A latere visis circularibus, 25.4  $\mu$  long., 21.2  $\mu$  lat., 6  $\mu$  isth.

We place this near *C. sphalerostichum* Nordst., in which the apex is flat and smooth, and *C. furcatospermum* W. & G. S. WEST, which also has a smooth centre to the semicell.

*C. margaritifera* [(Ehr.) Menegh. 1840] RALFS 1848. var. *quinquepunctatum* var. nova nobis, Bauline. Characterised by 5 granules, arranged in two rows, 2 near the isthmus and 3 above, in the middle of each semicell, which is otherwise smooth. Length 51  $\mu$ , breadth 39—42  $\mu$ , thickness 28  $\mu$ , isthmus 10  $\mu$ , (Fig. 2).

Granulis 5 in series transversas 2, granulis 2 prope isthmum et granulis 3 in medio semicellularum ordinatis, cetera glabra. Long. 51  $\mu$ , lat. 39—42  $\mu$ , crass. 28  $\mu$ , isth. 10  $\mu$ .

*C. pseudotithophorum* sp. nova nobis,

A v a l. Indian Meal. Small and staurastroid in front view, slightly broader than long, deeply constricted, the sinus subrectangular, and widely open with acute apex. Semicells obsemicircular, apex convex, lateral angles sub-acute. Cell wall minutely granulate. Vertical view without any median inflations. Length 32-32.5  $\mu$ , breadth 36  $\mu$ , isthmus 11  $\mu$ , (Fig. 3).

*Cosmarium* parvum, cellulae a fronte visae *Staurostrum* in memoriam revocant, paullo latiores quam longiores; profunde constrictum, sinu subrectangulo introrsum acuto extremo ampliato; semicellulis obsemicircularibus, apice convexo, angulis lateralibus subacutis. Membrana subtiliter granulata. A vertice visum lateribus in medio non tumidis, Long. 32—32.5  $\mu$ , lat. 36  $\mu$ , isth. 11  $\mu$ .

Distinguished from both *C. subraciborskii* Taft and *C. tithophorum* Nordst. in the lack of a protuberance in the vertical view (see SKUJA, 1949, xxviii), and from the former in the scattered granulation.

*C. quadrifarium* Lund. 1871. var. *Taylorii* var. nova nobis.

A v a l. Witless Bay Line, moorland pool. Distinguished from the type in the central part of each semicell bearing 7 large prominent granules arranged, either in two series (4+3), or in a shallow ellipse that shows a grading to the bi-seriate form. Lateral view showing 3 prominent granules on each margin in the middle of the semicell. Two pyrenoids in each semicell. Length 52—54.5  $\mu$ , breadth 38—40  $\mu$  thickness 28  $\mu$ , isthmus 16—18  $\mu$ . (Fig. 5). Named in honour of W. R. TAYLOR, the American algologist.

In medio singularum semicellularum granulis magnis prominentibus 7 aut in series transversas 2 aut ellipso tenui ordinatis; in latere semicellulae visae granulis 3 prominentibus medio semicellularum utrobique instructis; pyrenoidibus binis in unaquaque semicellula. Long. 52—54.5  $\mu$ , lat. 38—40  $\mu$ . crass. 28  $\mu$ , isth. 16—18  $\mu$ .

### *Micrasterias*

*M. Jenneri* Ralfs 1848 var. *lata* var. nova nobis.

A v a l. Bauline. Proportionately wider than the type and other varieties, the ratio of length to breadth being only 1.1 : 1. Membrane smooth. Length 169—187  $\mu$ , breadth 148—170  $\mu$ , polar lobe 86—102  $\mu$  wide, isthmus 32—40  $\mu$ . (Fig. 16).

Differt a formis quibuscumque ratione long./lat. = 1.1/1, membrana glabra. Long. 169—187  $\mu$ , lat. 148—170  $\mu$ , lob. pol. 86—102  $\mu$ , isth. 32—40  $\mu$ .

We have not seen any other specimens of *M. Jenneri* in these collections.

*M. tetraptera* W. & G.S. West 1898. v. *angulosa* Ir-Mar. 1952 forma *avalonensis* forma nova nobis.

A v a l. Bay Bulls, at ice-melt in April.

C e n t. between Buchans and Red Indian Lake, in a slime from a stream.

The whole cell markedly and equally hexagonal, the lateral lobes and polar lobe triangular, all incisions very narrow. At the sinus on each side of the incision between the lateral and polar lobes a row of small spines not reaching the base of the incision. Apical view elliptical with a sharp constriction in the middle, the sides rounded. Chromatophore lobed. Length 102—108  $\mu$ , breadth 92—100  $\mu$ , polar lobe 50—57  $\mu$ , isthmus 17  $\mu$ , thickness 26  $\mu$ . (Fig. 11). Mediocris paullo longius quam latius, cellulis totis sexangularis aequaliter profundissime constricta, sinu anguste lineari rotundate introrsus; lobo polari et lobis lateralibus triangulis, lobulis lateralibus ordinis tertii haud conspicuis, incisuris omnibus angustissimis cum incisuris polaribus profundissimis sed incisuris ulterioribus multo tenuioribus; lobis polaribus non productis, apicibus concavis, lateribus rectis angulis non spinatis; serie singula spinarum parvarum ad sinum medium et incisuris polaribus, sed non ad basin incisionis utrobique instructa. A vertice visae ellipticae in medio distincte constrictae, lateralibus rotundatis. Chromatophoris lobulatis. Long. 102—108  $\mu$ , lat. 92—100  $\mu$ , pol. lob. 50—57  $\mu$ , crass 26  $\mu$ , isth. 12  $\mu$ .

### *Staurastrum*

*S. avalonense* sp. nova nobis,

A v a l. Bauline (type locality); Witless Bay Line. C e n t. stream between Buchans and Red Indian Lake.

Small, deeply constricted, the sinus open, acute and strongly dilated outwards. Semicell elliptic-trapeziform with convex apex. Basal angles furnished with a short convergent spine, the lateral margins with 2 to 4 short spines, the apical margin granulate. Two parallel rows of granules within the upper margin, but the centre of each semicell is left smooth. Vertical view triangular, the sides almost straight, the angles furnished with 3 spines. Length 32.5 to 37  $\mu$ , breadth 43—47  $\mu$ , isthmus 14—16  $\mu$ . (Fig. 21).

Parvum, profunde constrictum, sinu aperto atque acuto, extrorsus valde ampliato; semicellulis elliptico-trapeziformibus apicibus convexis, angulis inferioribus spina brevi et convergenti ornatis; lateribus spinulis 2—4 ornatis, dorso infra margines granulorum seriebus duobus parallelis instructo membrana in area centrali glabra; a vertice visae triangulae lateribus fere levibus, angulis trispinatis. Long. 32.5—37  $\mu$ , lat. 43—47  $\mu$ , isth. 14—16  $\mu$ .

In shape alone near *S. gatniense* W. & G. S. WEST, but the ornamentation is distinctive.

*S. granulosum* (Ehr.) RALFS 1848. forma *minutissimum* forma nova nobis.

A v a l. N. Arm River, Holyrood. Much smaller than the type (var. *granulosum*) and forma *connexa* W. & G. S. WEST, length 18—21  $\mu$ , breadth with spines 18  $\mu$ , isthmus 9  $\mu$ , faintly granulate with a pair of spines at the angles. (Fig. 6).

Forma multo minor quam f. *typicum* (i.e. f. *granulosum*) et f. *connexum*, membrana leviter granulata spinis binis ad angulos instructa. Long. 18—21  $\mu$ , lat. cum. sp. 18  $\mu$ , isth. 9  $\mu$ .

The type, var. *granulosum*, also occurred at Holyrood, its only locality for these collections.

*S. ophiura* LUND. 1871. var. *nanum* var. nova novis.

A v a l. Waldron. Twice as long as broad, but much smaller than other varieties, 48  $\mu$  long, 75—81  $\mu$  wide with processes, 18—21  $\mu$  wide without processes. Vertical view 5-rayed, the processes serrate above and smooth below. Only 3 granules visible above the isthmus on each semicell. Conical projections on apical margin. (Fig. 30).

Differt a ceteris formis cellularum quippe quae duplicato longiores quam latiores simulque breves sint; dorso prominentibus conicis ornato. A vertice visae 5-radii praeditae qui in margine ventrali glabri, serrati in margine dorsali. A fronte visae supra isthmum 3 tantum granulis instructae in utraque semicellula. Long. 48  $\mu$ , lat. cum rad. 75—81  $\mu$ , lat. sine rad. 18—21  $\mu$ .

The type, v. *ophiura*, also occurred at Waldron as well as in other parts of Avalon.

*S. ornithopodum* W. & G. S. WEST 1896, var. *trigonum* var. nova nobis.

A v a l. Salmonier Line; Indian Meal. Differs from the type (See W. & G. S. WEST, 1896, pl. xvii, figs. 18—20) principally in having a triangular vertical view. In front view the apex is flat to slightly concave, and the apical spines emarginate; no basal ring of granules. Length 36—48  $\mu$ , breadth with processes 54—82  $\mu$ , isthmus 14—17  $\mu$ , isthmus 14—17  $\mu$ . (Fig. 26).

A verticae visae 3-angulae, long 36—48  $\mu$ , lat. cum rad. 54—82  $\mu$ , isth. 14—17  $\mu$ .

This variety should be compared with *S. concinnum* W. & G. S. WEST and *S. vestitum* RALFS. Some Salmonier specimens were parasitised by a Chytrid fungus.

*S. paradoxum* [(MEYEN 1829)] RALFS 1848. var. *zonatum* var. nova nobis.

A v a l. Duffy's Well. With a ring of granules at the semicell base, 4 visible in front view. Body somewhat elongate, the processes proportionately short, apex convex. 40  $\mu$  long without processes.



43  $\mu$  long and 47  $\mu$  wide with processes, isthmus 10  $\mu$ . (Fig. 25).

Ad basin semicellularum annulo granulorum a fronte visis 4 instructis; corpore elongato processibus in proportione curtioribus, dorso convexo. 40  $\mu$  long. sine proc. 43  $\mu$  long. et 47  $\mu$  lat. cum proc., isth. 10  $\mu$ .

*S. quadricornutum* ROY & BISS 1886. var. *heterospinum* var. nova nobis.

A v a l. Holyrood. Larger than the type, with 3 processes at each angle, the middle process almost equally bifid, the flanking two processes very unequal-bifid. Length with spines 35—36  $\mu$ , breadth 28—32  $\mu$ , isthmus 10  $\mu$ . (Fig. 8).

Differt a typo var. *quadricornuto* statura robustior, processibus 3 unoquamque angulo, quorum mediani aequaliter bifidi, ceteri inaequaliter, praeditis. Cum spinis 35—36  $\mu$  long, 28—32  $\mu$  lat., isth. 10  $\mu$ .

This spine conformation was illustrated without comment by TURNER (1892, pl. xvi., fig. 19), but our plants show it to a more marked degree.

*S. subcruciatum* COOKE & WILLS ex COOKE 1887 var. *Wrightianum* var. nov. nobis.

A v a l. Seal Cove. Differs from the type (var. *subcruciatum*) in having a ring of sharp teeth on the apex. The spine at the basal angle is stronger. Vertical view triangular, the sides weakly convex and the corner spine single and strong. Length 38  $\mu$ , breadth 34  $\mu$ , isthmus 16  $\mu$ , (Fig. 20).

Differt a typo dorso annulo singulo dentium acutarum praeditis, angulis inferioribus spino validiore ornatis. A vertice visa triangulares, lateribus laevissime convexis et spino singulo forte ad angules.

Named in honour of the Rev. DR. W. REES-WRIGHT, by whom the Avalon material was collected.

*S. turgescens* DE NOT 1867. forma *majus* forma nova nobis.

A v a l. Bauline (muddy trickle). Much larger than the type, and with open sinus. Length 50  $\mu$ , isthmus 18  $\mu$ . (Fig. 28).

varietas magis major sinu aperto., 50  $\mu$  long. 50  $\mu$  lat., 18  $\mu$  isth.

*S. Whiteanum* sp. nova nobis.

C e n t. Red Indian Lake, stream. Small, slightly longer than broad with deep constriction, the sinus open and acute. Semicells sub-trapeziform, the lower lateral margins strongly convex, without spines on the lower angles which are rounded. Apex strongly convex, with a pair of short processes, acutely-conical (not tipped with spines)

at each corner. Angles of semicells with only 2 series of granules. Vertical view usually 4-sided; lateral view similar to the front view. Length  $34\ \mu$ , breadth  $27\ \mu$ , thickness  $19\ \mu$ , isthmus  $10.5\ \mu$  across. No zygospores seen. (Fig. 82).

*Staurostrum parvum*, paullo longius quam latum profunde constrictum sinu aperto acuto. Semicellulis subtrapeziformibus laterali-bus inferioribus valde convexis, angulis rotundatis sine spines; dorso valde convexo unoquoque angulis processibus duobus curtis, acute conibus sine spinis. Angulis semicellularum 2 seriebus granulorum praeditis. A vertice visa quadrangularis. Lateris et frontis similes sunt.  $34\ \mu$  long.,  $27\ \mu$  lat.,  $19\ \mu$   $10.5\ \mu$  isth.

Distinguished from *S. monticulosum* Bréb. in Menegh. in its lack of spines, and its shape; it is about the size of f. *Arsenii* Iren.-Mar., but again differs in its lack of spines. We name this species in honour of MRS. A. WHITE from whom the material from Central Newfoundland was obtained.

## Bacillariophyta

### *Eunotia*

*E. arcadia* sp. nova nobis,

A v a l. Seal Cove; Witless Bay Line (18). Very small, valve straight, the ventral margin with its median part straight, impressed, the outer parts rounded convex; dorsal margin biundulate with capitate ends, sharply abstricted on the ventral margin: length  $10\text{--}12\ \mu$ , breadth  $3\ \mu$ , Transapical striations 18 in  $10\ \mu$ . Terminal nodules on the ventral margin displaced inwards at the base of the abstractions. (Fig. 47).

Valvae perparvae rectae, margine ventrali recta in medio leniter constricta ad apices convexa; margine dorsali biundulata; apicibus capitatis, perspicue in margine ventrali constrictis,  $10\text{--}12\ \mu$  longae,  $3\ \mu$  latae. Striae transapicales 18 in  $10\ \mu$ . Nodulis terminalibus prope margine ventrali in basi constrictionis intus coercitis. cf. *E. gibbosa* Grun. in V. H. — but smaller, denser striation and more graceful.

*E. bactriana* EHR. 1854. var. *minor* var. nova nobis.

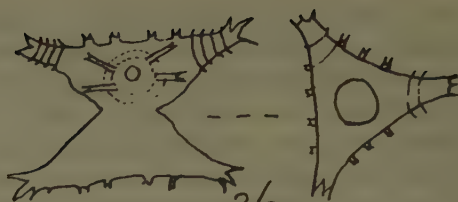
A v a l. Waldron; Bay Bulls. Only half the size of the type, length  $17\text{--}17.5\ \mu$ , breadth  $4\text{--}5.4\ \mu$ . Ends produced. The outer inflations on the dorsal side are more acute than the middle protuberance. Striation coarser than in the type, 10 to 12 in  $10\ \mu$ . (Fig. 43).

Paene duplo minoribus quam typo, apicibus productis inflationibus exterioribus in lateri dorsali acutioribus quam mediam. Striis robustioribus, 10 in  $10\ \mu$ ,  $17\text{--}17.5\ \mu$  long,  $4\text{--}5.4\ \mu$  lat.

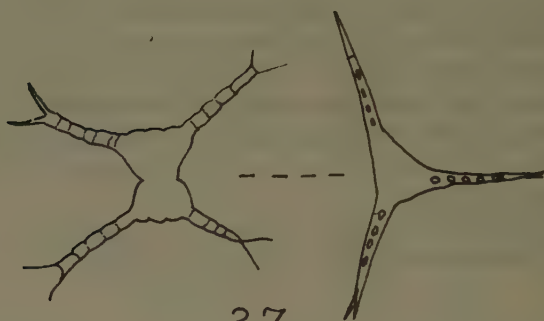
The type must now be designated as *E. bactriana* v. *bactriana*; it



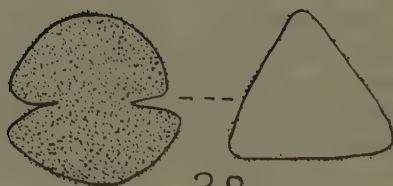
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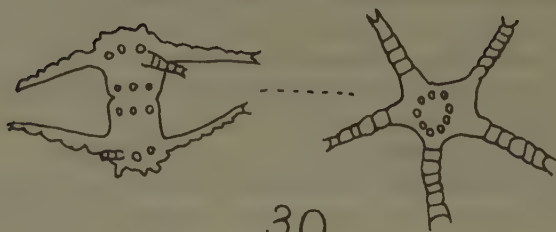
27.



28.



29.



30.

#### Plate IV

25 *Staurastrum paradoxum* v. *zonatum* var. nov. (scale A). 26 *Staurastrum ornithopodum* v. *trigonum* var. nov. (scale B). 27 *Staurastrum lacustre*. 28 *Staurastrum turgescens* f. *majus* f. nov. (scale A). 29 *Staurastrum megacanthum* f. *faroëns* BÖRGES. (scale B). 30 *Staurastrum ophiura* v. *nanum* var. nov. (scale B).

occurs in a number of localities in Newfoundland. Fig. 35 is transitional towards *v. auriculoides* BERG ex A. CL.-EUL.

*E. faba* (Ehr.) GRUN in V. H. 1881. f. *recta* forma nova nobis.

Aval. Bauline Crest. Differs from var. *densestriata* Østrup in having the venter quite flat, transapical striae only 16 in 10  $\mu$ . Terminal nodules displaced from the poles, 14  $\mu$  long, 3.5  $\mu$  wide. Fig. 70.

Differt ab varietate *densestriata* margine dorsali omnino plana, striis transapicalibus solum 16 in 10  $\mu$ , nodulis terminalibus ab apicibus distantibus. Longae 14  $\mu$ , 3.5  $\mu$  latae.

The type *E. faba v. faba* is widely distributed in Avalon, but is nowhere frequent; at Bauline Crest BERG's forma *d* was also detected.

*E. praemonos* A. BERG ex. A. CL. EUL. 1953 forma *recta* forma nova nobis.

Cent., Red Indian Lake (10). Differs from the type in having the dorsum straight, the ventral margin being shallowly concave. 37  $\mu$  long, 10.2  $\mu$  wide, transapical striae 8 in 10  $\mu$ . Fig. 64.

Differt ab typo margine dorsali recta, ventrali lenissime concava. Longae 37  $\mu$ , 10.2  $\mu$  latae; striae transapicales 8 in 10  $\mu$ .

*E. reversa* sp. nova nobis,

Aval. Bay Bulls at ice-melt. Valve with the ventral line two-hummocked, the depression between the bulges marked and even, suddenly tapering to the poles. Dorsal margin moderately convex, also gradually tapering to the poles. Terminal nodules at the poles recurved. 26  $\mu$  long, 5.5  $\mu$  wide, 13—14 transapical striae in 10  $\mu$ . (Fig. 33).

Valvae margine ventrali bigibba in medio valde et aequaliter constricta, ad polos praerupte attenuata; margine dorsali modice convexa ad polos leniter attenuata; 26  $\mu$  longae, 5.5  $\mu$  latae. Striae transapicales 13—14 in 10  $\mu$ . Nodulis terminalibus ad apices recurvatis.

The lobing on the ventral margin is most unusual in *Eunotia*, otherwise there would be a close similarity with *E. pectinalis* where the lobing is dorsal. A. CL. EULER's illustration 450 h., unspecified for locality or even name, though under the number given to *E. veneris* shows the same peculiarity and may be a more slender form of our plant.

*E. Smithii* sp. nova nobis.

Aval. Bay Bulls. Valve linear, the ventral side straight, dorsal side weakly convex, the ends sharply abstricted and curved dorsally,



capitate, the apical margin truncate, not produced ventrally. Trans-apical striae closely packed, all parallel, 24 in  $10\ \mu$ , the terminal nodules ventral at the poles. Length  $84\ \mu$  width  $8.5\ \mu$ . (Fig. 39).

Valvae lineares margine ventrali recta, margine dorsali leniter convexa, apicibus capitatis ad polos perspicue constrictis in dorsalem recurvatis, truncatis margine ventrali non protractis. Longae  $84\ \mu$ , latae  $8.5\ \mu$ . Striis transapicalibus confertissimis, omnino parallelis, 24 in  $10\ \mu$ , nodulis terminalibus in margine ventrali apicum positis.

*E. Nymanniana* Grun. in V. H. is under half the size and its ventral side is slightly curved: it has radial striae near the poles.

*E. triodon* Ehr. 1838.

The range of this interesting species permits its segregation into forms, which vary within their own size limits but are more readily recognised by their proportions of length to breadth. In some of the populations we have studied (e.g. from a bog between Buchans and Sandy Lake), these forms are sharply set off one against the other. Confusion may arise in making identifications as a figure in the 'Süsswasser-flora' (HUSTEDT, 1930, fig. 206) does not compare closely with other illustrations; it shows a ventral inflation which is not shown by BOYER (1916), MEISTER (1912), W. SMITH (1853/6) or VAN HEURCK (1896). Its dimensions are  $71\ \mu$  long,  $18\ \mu$  wide, i.e. 4 times longer than broad.

We consider that the type variety (var. *triodon*) has proportions  $1\frac{1}{2}$  to  $2\frac{1}{2}$  times longer than broad. This occurs at Aval. Bauline Crest and Bauline Road; Brigus Barrens. Cent. Sandy Lake neighbourhood (4, 6); Red Indian Lake (7); Buchans River (11, 12, 13). ROSS recorded *E. triodon* for N. Quebec. Fig. 68.

*f. elongata* FONTELL 1917, which takes plants  $4\frac{1}{2}$ —5 times longer than broad. Cent. between Buchans and Sandy Lake (4, bog), measuring  $74.2$ — $88\ \mu$  long,  $15$ — $18\ \mu$  wide, with shallow undulations. Fig. 67.

forma *magna* forma nova nobis, plants larger than the type, intermediate between it and *f. elongata* viz. 3 to  $3\frac{1}{2}$  times longer than broad, but without a ventral inflation.  $60$ — $77\ \mu$  long,  $17.5$ — $19\ \mu$  wide. Fig. 66.

Forma major quam typus, 3—3.5-plo longior quam lata, sed sine inflatione ventrali; minor tamen quam *f. elongata* Longae  $60$ — $77\ \mu$ ,  $17.5$ — $19\ \mu$  latae.

Cent. Between Buchans and Sandy Lake (4, bog).

N.B. v. *medioinflata* A. CL.-EUL. has a ventral inflation.

forma *minuta* BERG, 1939. with proportions of the type, 1.5—2 times as long as broad, with a gentle dorsal undulation.

Cent. Between Buchans and Sandy Lake (4, bog), measuring

20—43.5  $\mu$  long, 12.5—19.5  $\mu$  wide; these plants had the dorsal undulations a little more pronounced than BERG's specimens. Fig. 69. This analysis leaves the plants of HUSTEDT and A. CLEVE-EULER supra in an anomalous position by reason of their ventral inflations. The species was found at A v a l. 2, 3, 7, 9, 18a, 19, 23, but exact proportions for the specimens was not then taken; their dimensions varied between 64.5—72  $\mu$  long, 18—22.5  $\mu$  wide, and are presumably our forma *magna*.

*E. veneris* (Ktz.) DE TONI 1892, var. *bidens* var. nova nobis.

A v a l. Bauline Crest. Differs from the type in having a dorsal margin with two distinct elevations, length 19.5  $\mu$ , width 4.7  $\mu$ . Terminal nodules displaced from the poles; transapical striae 14 in 10  $\mu$ . Fig. 65.

Differt a typo margine dorsali duobus gibbis perspicuis. Longae 19.5  $\mu$ , latae 4.7  $\mu$ . Nodulis terminalibus ab apicibus distantibus; striis 14 in 10  $\mu$ .

#### *Achnanthes*

*A. terrae-novae* sp. nova nobis.

A v a l., Bay Bulls (Sample 1953). Very small, lanceolate with rounded sides, the ends obtusely rounded, only 13.5  $\mu$  long, 4.5  $\mu$  wide. Raphe-less valve with a very narrow pseudoraphe, the central area being a transverse band reaching the margin on both sides (contrast *A. Nathorstii* Brun), transapical striae 15—16 in 10  $\mu$ , almost vertical to the pseudoraphe, clearly punctate, broken on each side of the pseudoraphe near the valve margins by a narrow furrow which almost reaches the ends. Raphe valve with delicate filiform raphe, axial area very narrow. Central area a narrow transverse band reaching both margins and expanding a little outwards. Transapical striation strong, slightly radial throughout, 15—16 striae in 10  $\mu$ , neither markedly punctate nor interrupted. (Fig. 32).

Valvae perparvae lanceolatae apicibus obtuse rotundatis, longae 13.5  $\mu$ , latae 4.5  $\mu$ . Areovalva pseudorhapha angustissima, area centralis fasciam usque ad marginem percurrentem formans; striae transapicales 15—16 in 10  $\mu$  ad pseudorhapham paene perpendicularares, distincte punctatae, sulco angusto in utroque pseudorhaphae latere paene ad terminum percurrenti interruptae. Rhaphovalva rhapha delicate filiformata area axiali angustissima; area centralis fasciam angustam transversam usque ad utrumque margine, extrorsum dilatata. Striae transapicales robustae leniter radiantes nec valde punctatae nec interruptae, 15—16 in 10  $\mu$ .

This is a distinctive species by reason of the distinct band, and the difference in punctation.

*A. Wrightiana* sp. nova nobis,

A v a l., Bauline Crest. Elliptical with broadly-rounded ends, 14.9—15.8  $\mu$  long, 4.6 to 5.6  $\mu$  wide. Raphe-less valve with distinct pseudoraphe, very slightly widened in the middle to a small central area, but not reaching the margins, transapical striae radial, 10—11 in 10  $\mu$ , the median stria on each side alone shorter than the rest. Raphe-valve with a straight filiform raphe, the central pores approximate. Axial area very narrow, central area very small, not forming a transverse band. Transapical striae closer, slightly radial, 13 in 10  $\mu$ , with the median stria on each side alone shorter than the rest. Fig. 72.

Valvae ellipticae apicibus late rotundatis 14.9—15.8  $\mu$  longae, 4.6—5.6  $\mu$  latae. Areovalva pseudorhaphe distincta in media parte ad aream centralem parvam sed non ad marginem percurrentem dilatata; striis radiantibus 10—11 in 10  $\mu$ , utrobique stria mediana brevior quam ceteris. Rhaphovalva rraphe recta filiformis, poris centralibus approximatis, area centrali parvissima non fasciam formans. Striis densioribus 13 in 10  $\mu$ , leniter radiantibus utrobique stria mediana brevior quam ceteris.

Close to *A. kryophila* Petersen but with coarser structure; larger than *A. saxonica* KRASSKE in Rabh. in which the differences between the two valves are more obvious and the central area conspicuous.

*Navicula*

*N. buchansiana* sp. nova nobis,

C e n t., Buchans. *Punctatae*, valves lanceolate with the ends more or less produced, slightly rostrate, not capitate. 51  $\mu$  long, 12  $\mu$  wide. Axial area somewhat narrow; central area conspicuous, transversely elliptical, the central nodules prominent. Transapical striae 10 in 10  $\mu$ , radial in the middle and becoming almost perpendicular to the axial line towards the poles. Central striae equally short, all conspicuously punctate with about 25 puncta in 10  $\mu$ . Fig. 73.

Valvae lanceolatae apicibus plus minusve productis, leniter rotundatis, sed non capitatis. 51  $\mu$  longae, 12  $\mu$  latae. Area axialis modice angusta; area centrali distincta et transapicaliter elliptica. Striis transapicalibus radiantibus in media parte aequaliter longis, sub apicibus ad lineam mediam perpendicularibus, 10 in 10  $\mu$ , distincte punctatis, punctis circiter 25 in 10  $\mu$ .

This diatom has an outline similar to that of *N. rhyncocephala* in which the striae are lineolate.

*N. microcephala* (Ktz.) GRUN. 1868, var. *rostrata* var nova nobis,

A v a l., Witless Bay Line (Five Mile Pond). Differs from the type

in having clearly rostrate poles and slightly broader valves,  $18\ \mu$  long,  $4.5\ \mu$  wide. Striae about 30 in  $10\ \mu$ , perpendicular to the raphe. (Fig. 54).

Differt ab typo polis valde rostratis, valvis leniter latioribus. Longae  $18\ \mu$ , latae  $4.5\ \mu$ . Striae transapicales circiter 30 in  $10\ \mu$ , ad rapham perpendiculares.

*N. pulverentula* sp. nova nobis,

A v a l., Bay Bulls (sample 2015), obtained at the melting of the ice. M i n u s c u l a e, very small, the valves linear-lanceolate, 3 times longer than broad, with acutely-rounded poles,  $9\ \mu$  long,  $3\ \mu$  wide. Axial area narrow, the central area small and rounded, not transversely rectangular. Transapical striation strongly radial and shorter in the middle of the valve, nearly perpendicular to the raphe towards the poles. 16—18 striae in  $10\ \mu$ . (Fig. 59).

Valvae perparvae lineari-lanceolatae 3-plo longiores quam latae, apicibus acute rotundatis. Longae  $9\ \mu$ , latae  $3\ \mu$ . Area axialis angusta, area centralis parva rotundata non rectangulata. Striae transapicales in media parte curtiones et valde radiantes, prope polos fere perpendiculares, 16—18 in  $10\ \mu$ .

A distinctive minute species.

*N. subpupula* sp. nova nobis.

C e n t., bog near Buchans River (13). B a c i l l a r e s, valves linear with the poles gently produced and broadly rounded,  $30\ \mu$  long,  $4.6\ \mu$  wide. Raphe straight, the terminal nodule transapically widened. Axial area very narrowly lanceolate, scarcely widened to a central inflation. Polar area present around the terminal nodule, reaching the valve margins. Transapical striae very delicate, more than 30 in  $10\ \mu$ . Fig. 70.

Valvae lineares apicibus leniter productis et late rotundatis,  $30\ \mu$  longae,  $4.6\ \mu$  latae. Raphe recta, nodulis terminalibus margines attinget in area quo transapicaliter dilatatis; area axiali angustissime lanceolata paene ad aream centralem dilatata, striis transapicalibus delicatissimis, supra 30 in  $10\ \mu$ .

Differs from *N. pupula* Ktz by reason of its central area.

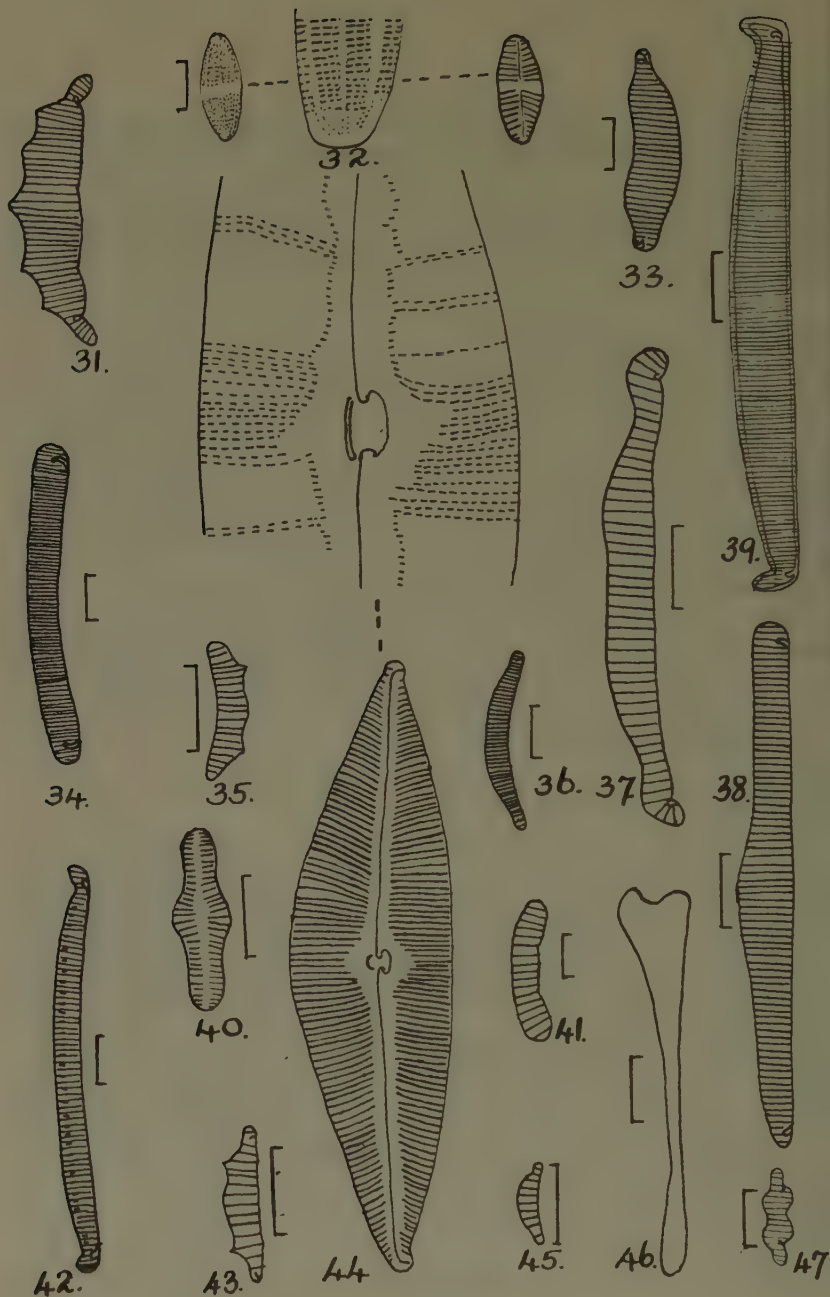
### *Pinnularia*

*P. gibba* Ehr. 1843. non W. Sm. non HUST. forma *unipunctata* forma nova nobis,

A v a l., Brigus Barrens, sample 1938. With an isolated punctum on one side the narrow fascia,  $85\ \mu$  long,  $9.5\ \mu$  wide. (Fig. 53).

Area centralis angusta poro unilaterali. Longae  $85\ \mu$ , latae  $9.5\ \mu$ .





# Plate V

10 scales alongside appropriate figures.

- 31 *Eunotia hexaglyphis* 32 *Achnanthes terrae-novae* sp. nov. rapheless and raphe valves, detail of striation on rapheless valve. 33 *Eunotia reversa* sp. nov. 34 *Eunotia angusta* forma 35 *Eunotia bactriana* v. *minor* var. nov. 36 *Eunotia tenella* forma 37 *Eunotia zygodon* forma 38 *Eunotia monodon* forma 39 *Eunotia Smithii* sp. nov. 40 *Fragilaria construens* forma. 41 *Eunotia angusta* forma. 42 *Eunotia denticulata* 43 *Eunotia bactriana* v. *minor* var. nov. 44 *Cymbella gastroides* Ktz. 45 *Eunotia septentrionalis* f. *paucistriata* W. & T. 46 *Actinella punctata* v. *curta* W. & T. 47 *Eunotia arcadia* sp. nov.

*P. monostigma* sp. nova nobis,

A v a l., Bay Bulls, sample W. & T. 1966. *D i v e r g e n t e s*, with linear-elliptic valves, the ends rounded and not produced,  $55.5\mu$  long,  $13.5\mu$  wide. Raphe simple, axial area moderately wide, central area widened and rounded. Striation divergent at the ends, radial in the middle with an isolated punctum opposite the shortest stria on one side in the middle, striae 11 in  $10\mu$ . (Fig. 56).

Valvis lineari-ellipticis apicibus rotundatis non protractis. Longae  $55.5\mu$ , latae  $13.5\mu$ . Rhapha directa, area axialis modice lata, area centralis rotundata. Striae transapicales 11 in  $10\mu$ , prope polos convergentes, in media parte radiantis poro unilaterali ad striam brevissimam spectanti.

*P. subtruncata* sp. nova nobis,

A v a l., Seal Cove, sample 1929; Windsor, sample W. a T. 1963. *P a r a l l e l i s t r i a t a e*. Valve linear, the sides weakly convex in the middle, the ends broadly rounded, subtruncate,  $29-30\mu$  long,  $7.5\mu$  wide. Axial area linear, narrow; central area rounded. Raphe simple. Transapical striae almost perpendicular to the axial area slightly divergent at the ends,  $9-10$  in  $10\mu$ . (Fig. 55).

Valvae lineares, marginibus in media parte leniter convexas, apicibus late rotundatis subtruncatis; longae  $30\mu$ , latae  $7.5\mu$ . Area axialis anguste linearis, area centralis rotundata. Rhapha directa. Striae transapicales  $9-10$  in  $10\mu$  ad lineam mediam fere perpendiculares apice versus leniter divergentes.

#### *Caloneis*

*C. pseudoholstii* sp. nova nobis,

A v a l., Waldron, sample W & T. 2006. Valve narrow-elliptical with strongly-produced ends, the poles rounded,  $54\mu$  long,  $16.5\mu$  wide. Axial area very narrow, central area small and rounded; transapical striae almost parallel, 12 in  $10\mu$ , the longitudinal lines distinct but narrow, placed near the margins (Fig. 57).

Valvae anguste ellipticae, apicibus valde protractis ad polos rotundatis. Longae  $54\mu$ , latae  $16.5\mu$ . Area axialis angustissima, area centralis parva rotundata. Striae transapicales, 12 in  $10\mu$ , fere parallelae, striae longitudinales marginales tenues sed visibiles.

Differs principally from *C. Holstii* (Cl.) Cl. in its strongly-produced ends.

#### *Anomoeoneis*

*A. canadensis* sp. nova nobis,

C e n t., Buchans (17, lake sediments). Linear lanceolate, the poles broadly rounded neither produced nor capitate,  $41\ \mu$  long,  $7.5\ \mu$  wide. Raphe straight and simple, sharply delimited on each side by a silica rib. Axial area very narrow, scarcely widened in the centre so that the central area is inconspicuous, not dilated. Transapical striae very slightly radial, more than 25 in  $10\ \mu$ , crossed by two hyaline longitudinal streaky lines. Fig. 74.

Valvae lineari-lanceolatae, apicibus late rotundatis nec productis nec capitatis,  $41\ \mu$  longae,  $7.5\ \mu$  latae. Rraphe recta et simplex inter duas costas validas posita. Area axiali angustissima, in media parte paene dilatata, areas centralis indistincta. Striae transapicales lenissime radiantes, plus quam 25 in  $10\ \mu$ , areae longitudinales duae angustae interruptae.

Close to *A. zellensis* (Grun.) Cl. but it lacks the undulate margins and the prominent rounded central area; in *A. styriaca* (Grun.) HUST. the central area is much more extended longitudinally than in this new species.

### *Mastogloia*

*M. lacustris* Grun. in SCHNEIDER 1878, var. *canadensis* var. nova nobis,

C e n t., lake sediments, Buchans.

Linear with produced ends, obtuse  $37.8$ — $48.5\ \mu$  long,  $7$ — $9.3\ \mu$  wide. Axial area narrow; central area a transverse band. Chambers 6 in  $10\ \mu$ , striae strongly radial throughout (cf. var. *doljensis*), punctate and only 16 in  $10\ \mu$ , the median series on both sides being shorter than the rest. Fig. 78.

Valvae lineares, apicibus obtusatis et productis, longae  $37.8$ — $48.5\ \mu$ , latae  $7$ — $9.3\ \mu$ . Area axiali angusta; area centrali fasciam prope marginem percurrentem formante. Loculi 6 in  $10\ \mu$ . Striae transapicalis omnino valde radiantes, punctatae, et solum 16 in  $10\ \mu$ , in media parte utrobique breviores.

This is quite linear and the striation is much more inclined than in *v. antiqua*.

### *Gomphonema*

*G. intricatum* Ktz. 1844 var. *tripunctatum* var. nova nobis,

C e n t., Buchans River (26). Differs from var. *semiapertum* A. MAYER in its more slender proportions,  $52.5\ \mu$  long,  $7\ \mu$  wide, and by having an isolated but strong punctum on the inner side of each of the three median striae opposite the unilateral central area; transapical striae 14 in  $10\ \mu$ , slightly radial. Fig. 77.

Differt ab varietate *semiaperto* in proportionibus gracilioribus,

longa 52.5  $\mu$ , lata 7  $\mu$ , et unoquoque puncto robusto singulo in partem interiorem 3 striarum mediarum e regione area centrali unilaterali. Striae transapicales leniter radiantes, 14 in 10  $\mu$ .

Three puncta in the neighbourhood of the central area are unusual in *Gomphonema*. cf. *G. dubravicense* Pant.

*G. semicruciatum* sp. nova nobis,

Aval., Seal Cove; Brigus Barrens; Hogan's Pond; Manuels. Astigmaticae, valve linear-clavate, both poles rounded to subacute, the foot pole slightly tapered, the top pole at times weakly produced, 17—24  $\mu$  long, 3—4.5  $\mu$  wide. Axial area narrow, the central area reaching the valve margin on one side only but lacking an isolated stigma. Transapical striation almost parallel, about 10 in 10  $\mu$ , punctation inconspicuous. (Fig. 58).

Astigmaticae. Valvae lineari-clavatae, polis rotundatis seu subacutis, polo inferiore leniter attenuato, polo superiore nonnquam exigue producto, longae 17—24  $\mu$ , latae 3—4.5  $\mu$ . Area axiali angusta, area centrali unilaterale marginem (sed astigmatica) sine puncto attinget. Striae transapicales fere paralleles, circa 10 in 10  $\mu$ , inconspicue punctatae.

#### *Gomphocymbella* O. MÜLLER 1910

Fossil species have been noted for North America; the genus is mainly African in its distribution.

*G. canadensis* sp. nov. nobis,

Cent., bog between Buchans and Sandy Lake (4). Frustule *Gomphonema*-like, heteropolar, ob lanceolate, the upper pole produced and broadly rounded, the valve tapering from its widest point gently towards the lower rounded pole, 70  $\mu$  long, 12  $\mu$  wide. Raphe excentric and very gently curved, the central pores distant. Axial area narrow, widening strongly into a lozenge-shaped central area that is conspicuous; no isolated punctum in these areas. Transapical striae somewhat radial, 21 in 10  $\mu$ , clearly punctate. Fig. 75.

Frustulae ob lanceolatae, *Gomphonema* similis, apicibus inaequalibus, polo superiore producto et late rotundato, valva ex amplitudine maximo ad polum inferiorem rotundatum attenuata. Longae 70  $\mu$ , latae 12  $\mu$ . Raphe excentrica, lenissime curvata, poris centralibus distantibus. Area axiali angusta, area centrali conspicue pastilloforme; Sine puncto in areis. Striae transapicales fere radiantes 21 in 10  $\mu$  manifeste punctate.

*G. sigmoidea* sp. nova nobis.

Cent., bog between Buchans and Sandy Lake (4). Frustule



somewhat sigmoid, lanceolate, the upper pole produced and subcapitate, the foot pole lying in the even curves of the sides, broadly rounded,  $67\ \mu$  long,  $10.3\ \mu$  wide. Raphe distinctly excentric and curved. Axial area very narrow, widening slightly into a small oval central area which has a conspicuous isolated punctum on the ventral side. Transapical striae very slightly radial in the middle, becoming sub-parallel towards the poles, 16 in  $10\ \mu$ , strongly punctate. Fig. 76.

Frustulae aliquantum sigmoidae, lanceolatae, longae  $67\ \mu$ , latae  $10.3\ \mu$ , polo superiore producto subcapitato, polo inferiore late rotundato, in flexibus aequis lateralium posuit. Rhaphe valde excentrica et curvata. Area axiali angustissima, in area centrali parva leniter dilatata: in latere ventrali puncto solo manifesto. Striae transapicales in medio lenissime radiantes, ad poles subparalleles 16 in  $10\ \mu$  valde punctatae.

Among a set of 'Species incertae' in KÜTZING (1849) there is an *Encyonema sigmoidea* with the earlier synonym, *Gloeonema sigmoidea* Ehr., 1845; the locality whence this incompletely described diatom was obtained was the mouth of the Demerara River, but the data given do not permit linking our Newfoundland diatom on to a dubious species, which indeed, seems to have been left unheeded by later authors, e.g. P. T. CLEVE.

### *Cymbella*

*C. microcephala* Grun in V. H. 1880/1, forma *intermedia* forma nova nobis,

Aval., Witless Bay Line, sample 1960. Connects forma *robusta* HUST. with var. *major* (V. H.) A. CL.-EUL. Ventral striae 13 in  $10\ \mu$ , the dorsal striae more distant, 10 in  $10\ \mu$ , length  $22.5\ \mu$ , width  $4.5-5.0\ \mu$ . (Fig. 48).

Formam *robustam* et varietatem *maiorem* jungit. Striae ventrales 13 in  $10\ \mu$ , striae dorsales distantiores 10 in  $10\ \mu$ . Longa  $22.5\ \mu$ , lata  $4.5-5.0\ \mu$ .

### *Rhopalodia*

*R. gibba* (Ehr.) O. MÜLL. 1895 v. *ventricosa* (Ktz.) V. H. 1896 f. *minutissima* forma nova nobis.

Cent., Buchans River (12). Much smaller than the type, only  $9\ \mu$  long,  $6\ \mu$  wide. Ribs 6 in  $10\ \mu$ . Fig. 79.

Valde minoribus quam typo, varietate *ventricosa*, solum  $9\ \mu$  longa,  $6\ \mu$  lata. Costis 6 in  $10\ \mu$ .

## EUGLENOPHYTA

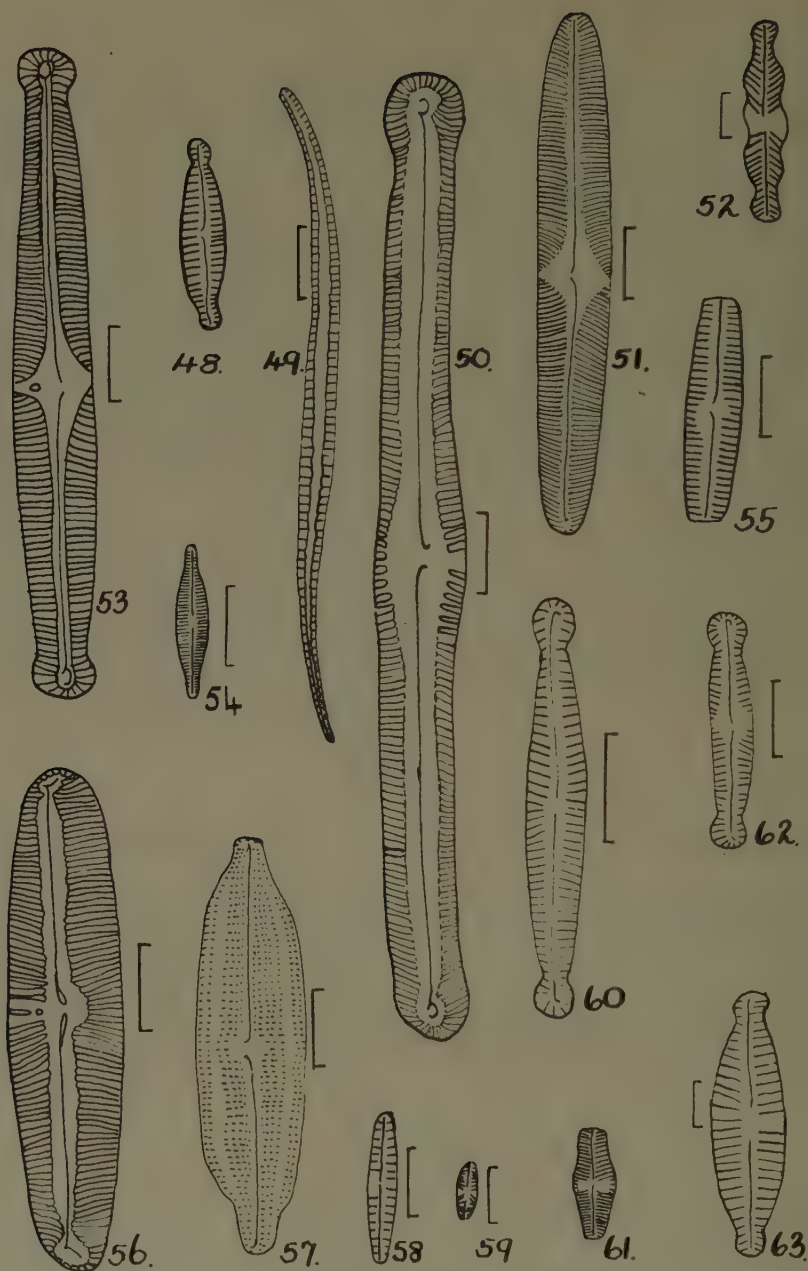
### *Entosiphon* STEIN

*E. Wrightianum* sp. nova nobis,

A v a l. Indian Meal.

Oval, broadest in the middle, the anterior end somewhat truncate and showing 3 longitudinal striae. Siphon short scarcely reaching the middle of the body. Chromatophores 4, 2 being large, cylindrical and laterally placed, and 2 being smaller and round. Length 50  $\mu$ . Breadth 38  $\mu$ . (Fig. 80).

Cellula ovata in medio latissima, antice sensim truncata cum 3 striis longitudinalibus. Gula curta paene ad mediam attinget. Cytoplasmatis granules paramylaceis 4, 2 magnis cylindricis et lateralibus, 2 parvis rotundatis. Longa 50  $\mu$ , lata 38  $\mu$ .



# Plate VI

10 μ scales alongside appropriate figures.

48 *Cymbella microcephala* f. *intermedia*. 49 *Stenopterobia arctica*. 50 *Pinnularia gibba* forma. 51 *Pinnularia subcapitata* aff. v. *robusta* Font. 52 *Pinnularia mesolepta* forma aff. v. *minuta* A. CL-EUL. 53 *Pinnularia gibba* f. *unipunctata* f. nov. 54 *Navicula microcephala* v. *rostrata* var. nov. 55 *Pinnularia subtruncata* sp. nov. 56. *Pinnularia monostigma* sp. nov. 57. *Caloneis pseudoholstii* sp. nov. 58. *Gomphonema semicruciatum* sp. nov. 59. *Navicula pulverulenta* sp. nov. 60. *Pinnularia Smithii* f. *minor* f. nov. 61. *Navicula ventralis* KRASSKE 62. *Pinnularia Smithii* f. *minor* f. nov. 63. *Pinnularia microstauron* forma.

## Part 2: A Consideration of the Taxonomy of Some Algae Found in the Newfoundland Collections.

Among the large number of taxa surveyed, a list of which is intended to form Part Three of this work, there are some which require nomenclatural discussion and the establishment of new combinations. These occur mainly in the diatoms, but a few desmids have also been under our consideration.

### *Desmids.*

*Closterium Dianae* var. *compressum* Klebs. *Aval.* 6, 9, 14a, 17, 19, 20. KRIEGER (1937—9) considered that plants lacking an apical pore (or notch) should be placed here, though with some reservation. This apical notch has often been overlooked as a diagnostic character, e.g. by W. & G. S. WEST (1904) although it was clearly depicted by RALFS (1848, pl. xxviii, figs. 5a, 5c), and later described by ARCHER in PRITCHARD's 'Infusoria' (1861) "with a very slight emargination at the upper outer extremity". On this account *Cl. Pegleri* FRITSCH has to be placed into the type variety, *Cl. Dianae* var. *Dianae*. IRÉNÉE-MARIE's illustrations in his 'Flore Desmidiace', (1939), must be referred to the variety.

*Closterium Libellula* varieties. We have pointed out in an earlier paper (1954) the desirability of approximating the taxa '*intermedium*' and '*interruptum*' which lie in this species. As our records show their history is as follows:—

*Penium Libellula* v. *intermedium* ROY & BISSETT 1894.

*Penium Libellula* v. *interruptum* W. & G. S. WEST 1897'

*Closterium Libellula* v. *intermedium* (ROY & BISS.) G. S. WEST 1914

*Closterium Libellula* v. *interruptum* (W. & G. S. WEST) DONAT 1926.

In our own paper (1954) the latter became, by implication, *Closterium Libellula* f. *interruptum* (W. & G. S. WEST) W. & T. 1954.

For both *Penium* and *Closterium* combinations the older epithet is *intermedium*, which we feel must be adopted as the varietal epithet. Though there are intergrades in the material we have seen it still



seems preferable to have some slight discrimination between 'interruptum' and 'intermedium', making the former subordinate, in which case it should be referred to as

*Closterium Libellula* v. *intermedium* f. *interruptum* (W. & G. S. WEST) nova comb. nobis,  
superseding our previous remarks.

*Closterium toxon* W. WEST, A v a l. Holyrood; Colinet Line (14a); Duffy; Witless Bay Line.

f. *sigmoideum* Ir.-Mar., A v a l. Colinet Line (14a), a slender sigmoid *Closterium* about 37 times longer than broad, 310  $\mu$  long, 8  $\mu$  wide in the middle and at the truncate apices. With 24 pyrenoids a high number for *C. toxon*. Wall smooth. Originally described from Canadian material. (Fig. 7).

*Cosmarium cosmetum* W. & G. S. WEST. A v a l. Holyrood, shallow water of pond. The characteristic reticulation of the membrane makes this distinctive. Length 54—57  $\mu$ , breadth 48.5—50.5  $\mu$ . Known for Nova Scotia. (Fig. 1).

*Cosmarium cucurbita* (BRÉB. in Desmaz.) RALFS, A v a l. 2, 3, 8, 9, 10a, 11, 13, 14a, 15, 17, 19, 21, 23. C e n t.

Though one of the widest distributed of desmids it is rarely frequent in any one sample.

f. *latior* W. & G. S. WEST, A v a l. Seal Cove, presumably new for America. These plants were more robust than previously recorded, length 54  $\mu$  long, 34  $\mu$  wide, isthmus 30  $\mu$  (Fig. 13).

*Cosmarium Lundellii* DELP.: we have not come across the type variety *Lundellii* in the Newfoundland collections but taxa of lower grades have been found.

v. *ellipticum* W. WEST A v a l. Holyrood.

v. *capense* (Nordst.) GRÖNBL. f. *minor* (FRITSCH) comb. nov. nobis, C e n t., Buchans River (26), measuring 65  $\mu$  long, 45  $\mu$  wide, isthmus 15  $\mu$  across, more slender than v. *ellipticum* f. *minor* STRÖM, and falling within the range of the desmid previously referred to as *C. capense* v. *minor* FRITSCH 1918. However, as *C. capense* was reduced to a variety of *C. Lundellii* by GRÖNBLAD, a new ascription is required.

*Cosmarium pachydermum* v. *minus* NORDST.

A v a l. SALMONIER, (10a) among *Sphagnum*. A small form, differing from var. *aethiopicum* W. & G. S. WEST and its form, forma *minus* Rich, in having a thick membrane, 2  $\mu$  across in these Newfoundland plants. Length 54  $\mu$ , breadth 40  $\mu$ , isthmus 12  $\mu$ . (Fig. 15).

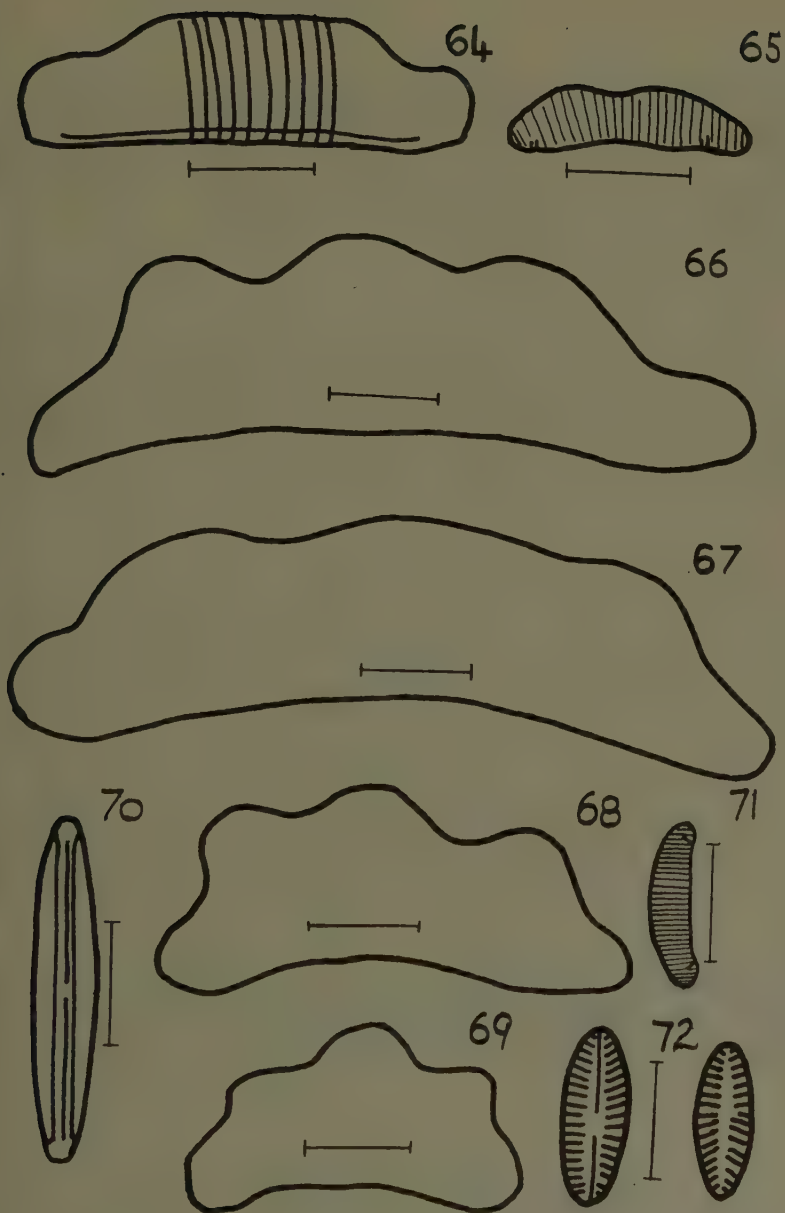


Plate VII

10  $\mu$  scales alongside appropriate figures.

64. *Eunotia praemonos* f. *recta* f. nov. 65. *Eunotia veneris* v. *bidens* var. nov.  
 66. *Eunotia triodon* f. *magna* f. nov. 67. *Eunotia triodon* f. *elongata* Font.  
 68. *Eunotia triodon* f. *triodon*. 69. *Eunotia triodon* f. *minuta* BERG. 70. *Navicula subpupula* sp. nov. 71. *Eunotia faba* f. *recta* f. nov. 72. *Achnanthes Wrightiana* sp. nov.

*Euastrum attenuatum* WOLLE.

A v a l. Holyrood, measuring  $54\ \mu$  long,  $35\ \mu$  wide, very similar to WOLLE's figure of *E. Hastingsii* WOLLE (1892, pl. xlii, f. 17) with a rectangular basal part and the whole plant squat. KRIEGER placed *E. Hastingsii* under this present heading. (Fig. 17).

*Micrasterias conferta* LUND.

A v a l. Seal Cove, marsh pool.

v. *hamata* WOLLE, A v a l. Seal Cove. Known for Canada. At the outlet of Waldron's Pond in August, a form appeared with strong coarse teeth on the polar lobe, those on the lobules being acute (cf. G. M. SMITH, 1924, pg. 44, fig. 4, and the drawing of *M. conferta* v. *hamata* in PRESCOTT & SCOTT, 1942 pg. 72, fig. 2.) Our plant is intermediate between the latter and the type. (Fig. 18).

*Micrasterias crux-melitensis* ((Ehr.) HASS.) RALFS.

A v a l. Seal Cove; Colinet Line (14a).

Known for Canada. A form with 2 sharp spines within the margin about the middle of the polar lobe has been observed, length  $100-101\ \mu$ , breadth  $93-97\ \mu$ , polar lobe  $42\ \mu$  wide, isthmus  $12\ \mu$ , thus less in size than the varieties *spinosa* Roll or *aequalis* Rich. (Fig. 12).

*Xanthidium armatum*. [(BRÉB. in Menegh.) RABH.] RALFS 1848.

The type variety, v. *armatum*, was found in A v a l. 3, 7, 9, 10a, 13, 17, 19, 20 and 23, and the var. *fissum* Nordst. in A v a l. Waldron pond outlet; large desmids in a moorland pool on the Witless Bay Line (23) may also be placed here,  $184\ \mu$  long,  $130\ \mu$  wide, isthmus  $34\ \mu$ .

var. *irregularius* W. WEST. A v a l. Salmonier Line (10a); Indian Meal. Recorded from Quebec. The Salmonier plants showed that though the simple spines were conical, the trifurcate spines had their bases clearly stalked as in var. *fissum*, length  $144-146\ \mu$ , breadth  $94-102\ \mu$ . (Fig. 24).

*Stauroastrum arctiscon* (Ehr.) LUND.

A v a l. MANUELS.

var. *truncatum* IRÉN.-MARIE. A v a l. HODGE-WATER. This distinctive variety has been observed in Canada and New Hampshire and may have a wider distribution in the Maritime Provinces (cf. WHELDEN, 1942). Our specimens measure  $166\ \mu$  long,  $155\ \mu$  wide with processes;  $86\ \mu$  long,  $60\ \mu$  wide without processes; isthmus  $32.5\ \mu$  across. Processes  $50\ \mu$  long, averaging  $8.5\ \mu$  across, their ultimate forks  $14\ \mu$  long,  $2.5-3.5\ \mu$  wide. (Fig. 22).

*Staurastrum brachiatum* RALFS.

A v a l. WALDRON; HODGEWATER; BRIGUS BARRENS; Witless Bay Line (23)

var. *Notarisii* RABH. A v a l. Salmonier Line, the specimens resembling WOLLE's figures (1884, pl. 63, figs. 29—31). Length with processes  $43\ \mu$ , without them  $14\ \mu$ ; breadth with processes  $65\ \mu$ . Isthmus  $11\ \mu$ . (Fig. 4).

*Staurastrum megacanthum* LUND.,

A v a l. Hogan's Pond; WALDRON. Known for Canada.

f. *faroense* BÖRGESSEN. A v a l. Bay Bulls, with spines shorter than in the type, var. *megacanthum* comb. nov., and smaller than var. *triangulare* GRÖNBL., without spines  $40\ \mu$  long, and  $40\ \mu$  wide; with spines  $40\ \mu$  long,  $53\ \mu$  wide, isthmus  $7\ \mu$  across, spines  $6.5\text{--}7\ \mu$  long. Previously recorded only for the Faeröes. (Fig. 29).

*Staurastrum sexcostatum* (BRÉB. in Menegh.) BRÉB. ex RALFS. var. *productum* (W. WEST) SCHMIDLE 1893.

C e n t., Red Indian Lake (7), known previously for Canada. SCHMIDLE's authority is required because W. WEST's epithet made in 1892 was of sub-specific rank, not varietal: the entries of synonyms in 'British Desmidiæ', Vol. 5, are not all correct.

*Diatoms*

*Tabellaria fenestrata* (LYNGB.) Ktz. 1884 var. *asterionelloides* GRUN in V. H. 1880/1.

A v a l., Seal Cove: WALDRON; HODGEWATER; Witless Bay Line (23). C e n t., Buchans River (11, 12). KNUDSEN (1952) proposed transferring this variety to *T. flocculosa* as *T. flocculosa* v. *asterionelloides* (GRUN. in V. H.) KNUDSEN. In the following year, A. CLEVE-EULER reduced it to *T. fenestrata* v. *lacustris* f. *asterionelloides*. We think it should retain varietal status.

*Tabellaria flocculosa* (ROTH) Ktz.

A v a l. and C e n t., present in almost every sample examined, but less so in quantity than *T. fenestrata*. The variety *Meisteri* A. CLEVE-EULER (= var. *genuina* KIRCHNER) occurs at A v a l. 6, 7, 9, 11, 15, 17, 29, C e n t., Buchans River 12, 26. KNUDSEN (1952) overlooked this important variety which we now consider to be the same as the diatom we described as v. *compressa* W. & T. 1952, which must be abandoned in favour of CLEVE-EULER's epithet. KNUDSEN included our variety under her type, v. *flocculosa*, but we do not subscribe to this opinion after consideration of CLEVE-EULER's description and illustration.



*Diatoma hiemale* (Lyngb.) HEIB. v. *Mayeri* nomen. nov. nobis,

A v a l. SALMONIER (10a, among *Sphagnum*), only  $30\ \mu$  long,  $4.5\ \mu$  wide, smaller than the German plants described as var. *acutum* A. MAYER. 1940. This epithet had already been occupied for a lanceolate structure, by HÉRIBAUD (var. *acuta* HÉRIB. 1903) whereas MAYER's diagnosis concerned a linear plant.

*Fragilaria undata*. W. Sm. f. *trinodis* (HUST. in RABH.) comb. nov. nobis is likewise required for *F. constricta* f. *trinodis* HUST. in RABH. 1930, consequent of merging *F. constricta* within *F. undata*. A v a l. Hogan's Pond from *Isoetes* mud; Bay Bulls marsh. These specimens measure  $42\ \mu$  long,  $7-9\ \mu$  wide.

*Fragilaria construens*. (Ehr.) GRUN.

C e n t., Buchans, lake sediments (17), Known for New Brunswick, etc. In a gathering from Manuels River we noted an abnormal form showing a bulge on one side of the valve near the pole,  $21\ \mu$  long,  $7\ \mu$  wide. (Fig. 40).

*Eunotia angusta* (GRUN.) BERG.

A v a l. BERG's forma  $\gamma$  occurred at WINDSOR; this has a median hump with an incision of either side on the ventral margin. Forma  $\varsigma$  occurred at Seal Cove; this has tapered ends,  $68\ \mu$  long,  $4\ \mu$  wide. An Indian Meal plant was smaller,  $33\ \mu$  long,  $4.5\ \mu$  wide, and is comparable with BERG's illustration, fig. 11. At Gull Island we noted a very small form with the ventral margin angular, (cf. BERG's forma  $\beta$ ), these angles being less pronounced and smaller than he illustrated, length  $14\ \mu$ , breadth  $3\ \mu$  (Figs. 34 and 41).

C e n t. between Buchans and Sandy Lake (4, 5); Buchans River, (12, 20, 23); Red Indian Lake (7, 10). These include geniculate specimens,  $30\ \mu$  long,  $3.5\ \mu$  wide, showing 10 transapical striae in  $10\ \mu$ . Others were larger than BERG's geniculate forms,  $49\ \mu$  long,  $5.5\ \mu$  wide, with 11 transapical striae in  $10\ \mu$ .

The species has been recorded from Scotland and Australia.

*Eunotia arcus* Ehr. var. *subalpina* FONTELL 1917 (including var. *fallax* HUST. in RABH. 1930)

C e n t. Buchans (17, lake sediments, measuring  $40.6\ \mu$  long,  $4.5\ \mu$  wide, with up to 10-transapical striae in  $10\ \mu$ ). The two taxa which we here place together differ only in the density of striation, between 8 in  $10\ \mu$  and 10 in  $10\ \mu$  at the most (HUSTEDT), not equidistant (FONTELL). HUSTEDT's illustration likewise shows an uneven spacing of striation. FONTELL's epithet, based on Scandinavian material, has priority. MÖLDER placed it in the type (1937).

*Eunotia curvata* (Ktz.) LAGERST. forma *Bergii* nomen novum nobis,

A v a l. Seal Cove; BAULINE CREST; BRIGUS BARRENS; WALDRON. This graceful diatom is forma  $\beta$  in BERG's study. These Newfoundland specimens have the range 22.4—39  $\mu$  long, 2.0—3.2  $\mu$  wide, somewhat smaller than the Scandinavian diatoms depicted by BERG.

v. *campyla* (HILSE) comb. nov. nobis, will be required for *E. lunaris* v. *campyla* HILSE. A v a l. Paradise, plants with both margins undulate, 127  $\mu$  long, 6  $\mu$  wide. Known for Central Europe.

f. *major* (GRUN. in V. H.) W. & T. 1958 has already been indicated by us as a new combination.

A v a l. BRIGUS BARRENS; these plants did not reach the dimensions of v. *maxima* infra, 98  $\mu$  long, 3.5  $\mu$  wide, the curvature shallow; transapical striae 15 in 10  $\mu$ .

v. *maxima* (MEISTER) comb. nov. nobis will be required for *E. lunaris* v. *maxima* MEISTER. A v a l. Seal Cove, up to 126  $\mu$  long, 5  $\mu$  wide. Recorded for Switzerland.

The new combinations became necessary with the re-establishment of *E. curvata* published by ROSS in POLUNIN for all had been linked on to the better-known name *E. lunaris*. ROSS did not state a case, but quotes the two names only.

*Eunotia denticulata* (BRÉB. ex Ktz.) RABH.,

A v a l. Indian Meal; the material showed transitions towards var. *fennica* HUST. in RABH. in size (e.g. 30  $\mu$  long, and 3  $\mu$  wide, 32  $\mu$  x 3  $\mu$ , 35.5  $\mu$  x 3.5  $\mu$  x 6  $\mu$ , with 8 marginal teeth in 10  $\mu$ ). We also found a form with teeth displaced intra-marginally from the dorsum, about 10 in 10  $\mu$ , unevenly placed, the transapical striae being 20 in 10  $\mu$ ; 42  $\mu$  long, 3  $\mu$  wide (Fig. 42). Cent. between Buchans and Sandy Lake, measuring 35—39  $\mu$  long, 4.6—50  $\mu$  wide. European records noted.

*Eunotia diadema* Ehr. var. *tetraodon* (Ehr.) A. CL. EUL. f. *minuta* (BERG) nom. nov. nobis is required for *E. tetraodon* f. *minuta* BERG.

A v a l. Bay Bulls (Sample 1953), only 20  $\mu$  long, 10  $\mu$  wide.

*Eunotia diodon* Ehr.

A v a l. 3, 6, 7, 9, 12, 15, never abundant. Cent. pool near Red Indian Lake (7); Buchans River (26). HUSTEDT's illustration (1930, f. 207) in the 'Süsswasserflora' yields measurements of 30  $\mu$  long, 8  $\mu$  wide, which are double the dimensions given in the text. He is at variance with other diatomists (e.g. VON SCHÖNFELDT 1913 and VAN HEURCK 1896) in presenting such small sizes for the type.

var. *minor* GRUN. sensu FONTELL forma *constricta* FONTELL

A v a l. Indian Meal; Seal Cove. C e n t. between Buchans and Sandy Lake. 24—30  $\mu$  long, 7—10.5  $\mu$  maximum width, 5—7  $\mu$  wide at the constriction. Known for Sweden.

*Eunotia hexaglyphis* Ehr.

A v a l. BRIGUS BARRENS; BAY BULLS. At BRIGUS in several collections has occurred a form with the poles markedly reflexed and produced, 33.5—43.5  $\mu$  long, 9  $\mu$  wide. (Fig. 31). C e n t. Red Indian Lake (10, pool).

*Eunotia monodon* (Ehr.) Ehr.

A v a l. 3, 7, 9, 11, 15, 17, 18a, 21, 22, 29. C e n t., Red Indian Lake (7, 10, in pools); Buchans River (20, 22). At Tanglewood a form had an inflated middle part resembling *E. Tschirchiana* O. MÜLL., 70—96  $\mu$  long, 7—9  $\mu$  wide, but with the striae evenly spaced. (Fig. 38). Known generally in Canada, including New Brunswick.

*Eunotia septentrionalis* Östrup.

A v a l. 2, 3, 7, 9, 10, 11, 12, 15, 18a, 19, 25, widespread and at times frequent. Some specimens show the dorsum almost straight, 10—15  $\mu$  long, 3—3.5  $\mu$  wide. Recorded for Labrador etc.

*f. paucistriata* W. & T. A v a l. Hogan's Pond. Only 10 striae in 10  $\mu$ ; 10  $\mu$  long, 3  $\mu$  wide. (Fig. 45).

*Eunotia tenella* (GRUN. in V. H.) A. CL., 1895

A v a l. MANUELS; Colinet, where the specimens had more than 20 striae in 10  $\mu$ , 23  $\mu$ , long, 2.5  $\mu$  wide, thus more slender than usual, the venter a little more concave. (Fig. 36). C e n t., Red Indian Lake (7, pool); Buchans River (13, bog), measuring 14  $\mu$  long, 2.8  $\mu$  wide. Known for Nova Scotia and North Quebec. A. CLEVE had raised this to specific rank in 1895 before HUSTEDT's illustration in A. SCHMIDT's Atlas.

*Eunotia zygodon* Ehr.

A v a l. BRIGUS BARRENS; the dorsal indentation was shallow, the capitate ends strongly recurved ventrally, 56  $\mu$  long, 6.5  $\mu$  wide, with 8—9 transapical striae in 10  $\mu$ . (Fig. 37). Known for New England States.

*Actinella punctata* LEWIS.

A v a l. Witless Bay Line, A full discussion of this interesting species, and the establishment of the variety (which has also been seen in tropical West Africa) is available in WOODHEAD & TWEED 1957. (Fig. 46).

*Navicula Wrightiana* nomen novum nobis.

A v a l. BRIGUS BARRENS. C e n t. Sandy Lake (5); near Buchans River (13), our specimens measuring 18—22  $\mu$  long, 5.6—6.5  $\mu$  wide, the striae only just visible in styrax. The new name is required for *Navicula vitrea* (Öst.) HUST. in PASCHER, 1930, as the epithet had already been occupied by P. T. CLEVE in 1880 (cf. CLEVE 1894/5, Vol. 1, pg. 111) and cannot be employed for ÖSTRUP's taxon.

*Pinnularia biceps* GREG. f. *biceps* is known for several localities in both Avalon and Central districts. As a result of the adoption of the epithet *P. biceps* for *P. interrupta* new combinations are necessary for certain formae and varieties which we have provided where necessary:

f. *constricta* (MANGUIN) W. & T. 1958. A v a l. SALMONIER (10a); Bay Bulls. These specimens measure 22.5—33  $\mu$  long, 3.5—6.0  $\mu$  wide. This combination replaces *P. interrupta* f. *constricta* MANGUIN 1941, a Pyrenean form.

It should be noted that *P. interrupta* v. *amphirhynchus* A. CL.-EUL. is now considered by MADAME CLEVE-EULER to be attached to *P. obliquistriata* as v. *amphirhynchus* (A. CL.-EUL.) A. CL. EUL. We have seen this at A v a l. BRIGUS BARRENS.

*Pinnularia gibba* Ehr. non. W. Sm.

A v a l. In most of the material, at times in abundance. C e n t. one of the most frequent diatoms in these collections.

Its nomenclature has been one of considerable confusion. In litt. Ross writes (Feb. 1951) "I am convinced now that the forms to which I gave the names *Pinnularia abaujensis* (Pant.) Ross and *P. parvula* (PRITCH.) CLEVE-EULER in my paper on Canadian Eastern Arctic Diatoms belong to the same species. Also I feel reasonably sure, with HUSTEDT (Süssw.-Flora Mitteleur. 10 2 Aufl.: 327 1930) that the original *P. gibba* Ehrenb. belongs to this species also. Most later figures labelled *P. gibba* Ehrenb. certainly do. I should now, therefore, follow HUSTEDT and call the species *P. gibba* Ehrenb. although with some slight reservation on the correctness of so doing owing to a technical nomenclatural point about the original publication. *P. stauoptera* (GRUN.) RAB. is identical with this species'.

"MAYER (Denkschr. bay. bot. Ges. 13 : 41 & 130, 1917) maintains that there is a separate species from the above which was described as *P. gibba* Ehrenb. by W. SMITH (Syn. Brit. Diat. 1; 58, 1853) and CLEVE (K. svenska Vetens Akad. Handl., n.f., 27 (3); 82 1895). If he is right, and after examining W. SMITH's specimens I incline to agree with him, the name *P. gibba* cannot be used for this species, and it does not seem to have been described under any other".

"*P. tabellaria* Ehrenb. is a quite distinct species, although specimens



really belonging to *P. gibba* Ehrenb. have been referred to it at times.”

“The characters of the various species are:—

*Pinnularia gibba* Ehrenb. = *P. stauroptera* (GRUN.) RAB., *P. parvula* (PRITCH.) CLEVE-EULER and *P. abaujensis* (PANT.) ROSS. Valves tapering towards the apices, sometimes gently gibbous at the centre, apices usually subcapitate, cuneate but occasionally rounded. Length  $30\ \mu$ — $150\ \mu$ , breadth  $7\ \mu$ — $15\ \mu$ . Striae  $8.5$ — $10$  in  $10\ \mu$ , markedly separate from one another, gently radiate at the centre where they are often interrupted, strongly convergent at the apices. Axial area broadening gradually towards the large elliptic central area. Terminal fissures slightly hooked. Figures: HUSTEDT in PASCHER Süssw.-Flora Mitteleur. 10 2 Aufl.: fig. 600 a and b, 601, 602, 604, 1930. (Note: *P. mesogongyla* Ehrenb. does not, in my view, belong here but is a separate species).”

We are in agreement with these views and propose to name SMITH's plants *P. Smithii* q.v.

At Windsor (sample 1963) a *P. gibba* form was noted in which the axial area occupied a little more than a third of the total valve breadth,  $120\ \mu$  long,  $12\ \mu$  wide. The central striae were loosely placed,  $8$ — $10$  in  $10\ \mu$ , interrupted on one side, the striation becoming denser towards the poles,  $10$  in  $10\ \mu$ , sometimes curved. (Fig. 50).

The following new combinations are required:

var. *Clevei* (MEISTER) comb. nov. nobis for *P. stauroptera* var. *Clevei* MEISTER.

var. *interrupta* (CL.) comb. nov. nobis for *P. stauroptera* var. *interrupta* CL.

*Pinnularia mesolepta* (Ehr.) W. SM. (Var. *genuina* (GRUN.) MEISTER).

A v a l. In most places but seldom frequent. C e n t. Red Indian Lake; Buchans River; between Buchans and Red Indian Lake; Millertown; Rothermere Road. Recorded for New Brunswick, Arctic Canada, etc. At Bauline (sample 1980) and Tanglewood, there occurred a very small form,  $18.5$ — $24\ \mu$  long,  $4.0$ — $4.5\ \mu$  wide, which had some affinity with var. *minuta* A. CL.-EUL. (Fig. 52).

*Pinnularia microstauron* (Ehr.) CL.

A v a l. and C e n t. in most localities, at times frequent. Known for Labrador, New Brunswick etc. At Brigus (sample 1948) a small form,  $30\ \mu$  long,  $7.5\ \mu$  wide with  $10$ — $11$  striae in  $10\ \mu$ , slightly radial (cf. Ross, 1947) but the striation interrupted on both sides, though the gaps are not strictly opposed to form a regular fascia. (Fig. 63).

*Pinnularia Smithii* nomen novum nobis. This is W. SMITH's conception of '*P. gibba*', which is also the *P. gibba* visualised by P. T. CLEVE, and A. MAYER (according to ROSS *in litt.*), also by A. CLEVE-EULER. It requires a new name, for which we make the above suggestion, appending Ross's description (*in litt.*) "Valves linear, gently gibbous in the centre, tapering gradually towards the subcapitate ends, just proximal to which it is constricted. Length  $40\ \mu$ — $100\ \mu$ , breadth (6)— $7\ \mu$ — $8\ \mu$ . A more slender form (than *P. gibba* EHR.) Striae  $10.5$ — $12$  in  $10\ \mu$ , gently radiate at the centre, where they are very rarely interrupted, strongly convergent at the apices, comparatively closely packed. Axial area narrow, central area elongate-elliptic, but not very broad. Terminal fissures slightly hooked."

This is a distinctive diatom; we have seen it in our British collections among populations of *P. gibba* Ehr.; from these we have reduced Ross's record of breadth to  $6\ \mu$ . A v a l. 9, 11, 15, 19, 29. C e n t. Sandy Lake (5); Buchans River (13, bog).

The following form has also to be taken into account:

forma *minor* forma nova nobis. A v a l. Tanglewood. Smaller than the type,  $27$ — $30\ \mu$  long,  $4.5$ — $5.0\ \mu$  wide. (Fig. 60). forma *minor*, longae  $27$ — $30\ \mu$ , latae  $4.5$ — $5.0\ \mu$ .

#### *Pinnularia subcapitata* GREG.

A v a l. Seal Cove (Measuring  $41\ \mu$  long,  $5.5$  wide): Bauline Road; BRIGUS BARRENS. Cent. Red Indian Lake; Millertown. All the specimens in these collections lacked a transverse band. Many writers have described the species to possess a transverse band, but ROSS's examination of GREGORY's type material shows this interpretation to be incorrect; the original specimens lacked a fascia. Hence, var. *stauroneiformis* GRUN. in V. H. 1880/1 should be employed to specimens with a band. (cf. PATRICK, 1945). At Seal Cove we noted a form  $68.5\ \mu$  long,  $8.5\ \mu$  wide, the sizes given for var. *robusta* FONTELL, but it had a more delicate striation, 16 in  $10\ \mu$ . (Fig. 51).

#### *Anomoeoneis zellensis* (GRUN.) CLEVE.

In addition to var. *typica* ROSS in Polunin (found in two localities in each of the two districts), there occurs var. *Hustedtii* nomen novum nobis. C e n t. lake sediments, Buchans, measuring  $18.6\ \mu$  long,  $4\ \mu$  wide. In PASCHER, 1930, HUSTEDT described a var. *linearis*, which he had originally published in 1922, but the epithet had already been occupied by ÖSTRUP (1910) for the diatom later illustrated by ROSS (1947) for Arctic Canada. It is apparent that HUSTEDT's description does not apply to this illustration, and that he had some other diatom in mind when he erected his own var. *linearis*, e.g. the sides

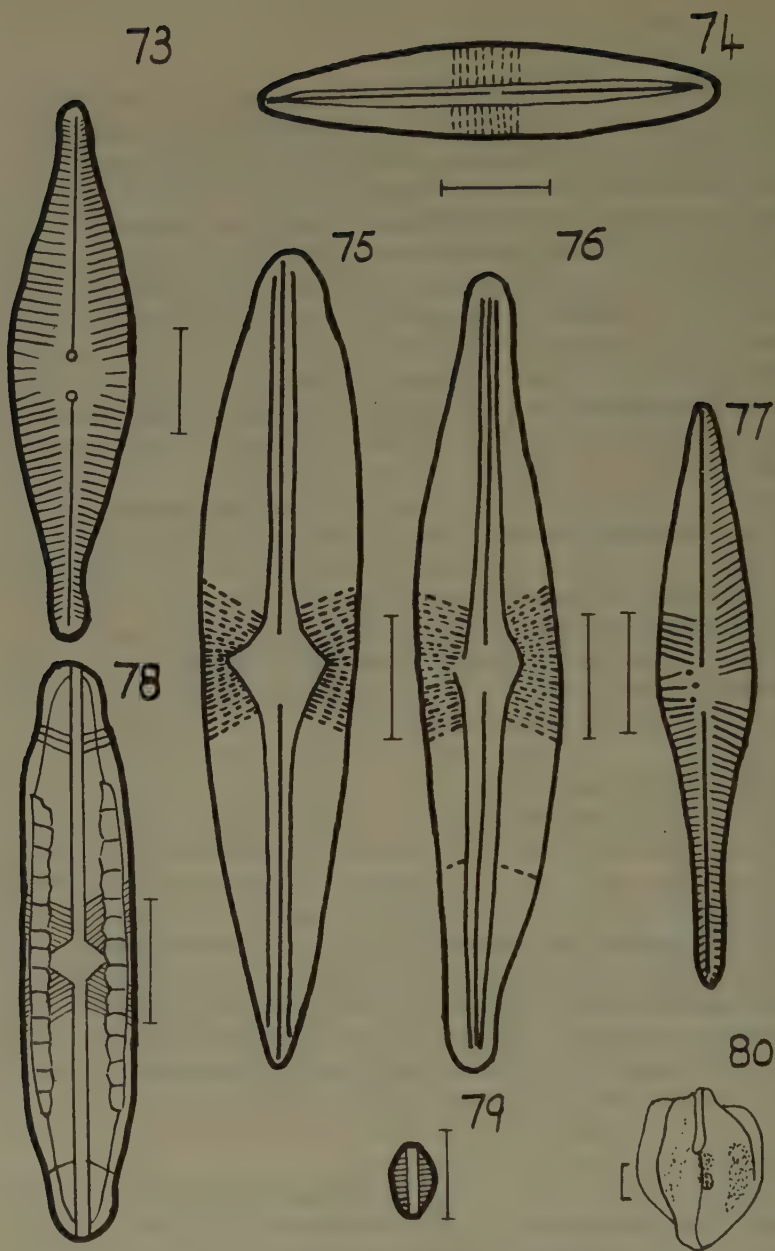


Plate VIII

10  $\mu$  scales alongside appropriate figures.

73. *Navicula buchansiana* sp. nov. 74. *Anomoeoneis canadensis* sp. nov. 75. *Gomphocymbella canadensis* sp. nov. 76. *Gomphocymbella sigmoidea* sp. nov. 77. *Gomphonema intricatum* v. *tripunctatum* var. nov. 78. *Mastogloia lacustris* v. *canadensis* var. nov. 79. *Rhopalodia gibba* v. *ventricosa* f. *minutissima* f. nov. 80. *Entosiphon Wrightianum* sp. nov. 81. *Cosmarium buchansianum* sp. nov. 82. *Staurostrum Whiteanum* sp. nov. (a) front view, (b) side view.

are parallel instead of gently constricted. In the PASCHER volume "stumpf vorgezogenen Rändern" must be a typographical error, for the meaning is a reference to the poles. A. CLEVE-EULER has remarked that a new name would be required, but she has not supplied one. We propose to re-name HUSTEDT's taxon, which will then include our plant from Buchans.

*Diploneis oblongella* (Näg. ex Ktz.) CLEVE.

New combinations are required, following the establishment of *D. oblongella* as the specific name instead of *D. ovalis*, to which they were originally attached (ROSS, 1947).

var. *pumila* (GRUN.) comb. nov. nobis. for *D. ovalis* v. *pumila* (GRUN.) Cl. 189. A v a l. Salmonier (sample 1983), measuring 21  $\mu$  long, 9—13  $\mu$  wide.

var. *rhombica* (A. MAYER) comb. nov. nobis for *D. ovalis* var. *rhombica* A. MAYER 1933. A v a l. MANUELS. Recorded for Germany.

*Stauroneis phoenicenteron* (NITZSCH) Ehr. 1843 forma *Dippelii* nomen novum nobis.

A v a l. Seal Cove; BAULINE; BRIGUS BARRENS; BAY BULLS. Known for Europe. BRUN and PERAGALLO published 'f. *gracilis*' in 1893, thus pre-dating DIPPEL's creation of 1904. It is possible that the same diatom was independently described, but it is difficult to be certain as there is no illustration of BRUN and PERAGALLO's specimens. It seems preferable to allocate a new epithet for DIPPEL's plants rather than perpetuate an invalid asuge.

*Gomphonema acuminatum* Ehr. var. *intermedium* GRUN. in V. H. 1880/1.

A v a l. Holyrood. This variety had already been reported in America under var. *elongatum* (W. Sm.) V. H. Our plant is not used in the sense of forma *intermedia* DIPPEL (1905, pg. 96, f. 204), and as the epithet had already been occupied by GRUNOW, DIPPEL's plant requires a new name for which we propose forma *Dippelii* novum nobis.

*Gomphonema gracile* Ehr. 1838 var. *Clevei* nomen novum nobis (= var. *lanceolatum* auct.)

A v a l., Tanglewood and Hogan's Pond; BRIGUS BARRENS, measuring 42.5  $\mu$  long, 8.4  $\mu$  wide.

This plant was named in the sense of HUSTEDT (1930) where it has the authority '(Ktz.) CLEVE'. KÜTZING (1849) did not credit himself with a *Gomphonema lanceolatum*, which BOYER listed in error as appearing in Bacill. p. 87, t. 29, f. 73; ZANON (1938) has already

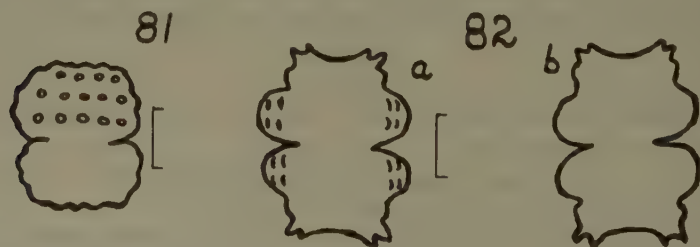


corrected this mistake. ELMORE (1922) indicated that this particular figure and epithet are synonymous with *Gomphonema lanceolatum* Ehr. (Amer. pl. 2, 1. 37, 1843) which (a) would antedate KÜTZING's use of the specific epithet by a year, rendering his authority invalid if, indeed, he had ever made it. (b) is the accepted basis for the full species kept in our standard systematic lists, e.g. HUSTEDT, 1930, pg 376.

P. T. CLEVE (1895) listed the variety for KÜTZING 1844, Bacill. 87, xxx, 59; when this is traced in KÜTZING's own later work, 'Species Algarum, 1849' it is found to be synonymous for EHRENBURG's Amer. Tab. 2, 1, 37, 1843 making it quite clear that the pagination data regard the *G. gracile* var. *lanceolatum* in CLEVE's 'Synopsis' as *G. lanceolatum* Ehr. Nearly all the authors of recent years take 'Ehr. Amer. 2, 1, 37' to be the species *G. lanceolatum*. But, undoubtedly, there is a different diatom, the one we are recording, which has to be placed within *G. gracile*, and which requires naming under Article 75 of the International Code; we suggest var. *Clevei* as the most suitable epithet.

*Gomphonema truncatum* Ehr. 1932. The re-establishment of *G. truncatum* as the name of this diatom necessitates changes in the taxonomy of A. MAYER's forms (1928) which were described originally as European forms of *G. constrictum* Ehr. We have already noted var. *capitatum* (Ehr.) W. & T. 1954, found here in A v a l. 2, 3, 6, 9, 10, 11, 12, 14b (frequent), 17, 18a, 21, 24. (more common than the type as a rule). P. T. CLEVE has recorded it for Canada. In addition there are v. *capitatum* f. *robustum* (A. MAYER) comb. nov. nobis, A v a l. 3, 6, 7, 9, 11, 12, quite common and conspicuous on account of its distinctive shape. Required for *G. constrictum* v. *capitatum* f. *robustum* A. MAYER.

v. *capitatum* f. *turgidum* (A. MAYER) comb. nov. nobis. A v a l. BAULINE (9b); MANUELS, Required for *G. constrictum* v. *capitatum* f. *turgidum* A. MAYER.



*Cymbella gasteroides* Ktz.

A v a l. 7, 9, 10a, 11, 29. At SALMONIER (sample 1983) the striation was of varying lengths especially around the central area, making the

outline of the areas irregular. (Fig. 44) Known for Labrador.

*Cymbella ventricosa* var. *Ag. genuina* A. MAYER is widely dispersed and common in both series.

var. *lunata* (W. Sm. in Greville) comb. nov. nobis, A v a l. 3, 7, 11, 15, 17, with the type and not infrequent. C e n t. Millertown. The trivial name was applied in the first instance to *Cymbella lunata* W. SMITH in Greville which became *Encyonema* in VAN HEURCK's Synopsis.

var. *Mayeri* (RABH.) W. & T. 1958. A v a l. Hogan's Pond. C e n t. Buchans (17). This stems from *Encyonema ventricosa* var. *laevis* (RABH.) A. MAYER; there is already a *Cymbella ventricosa* var. *laevis*, annexed for a diatom described by NÄGELI in KÜTZING's 'Species Algarum', which is referred to nowadays as *Cymbella laevis* NÄG. ex Ktz. by some authors.

*ventricosa* f. *minus* (A. MAYER) W. & T. 1958 has been seen at C e n t. Buchans (17).

*Amphora Ehrenbergii* nomen novum nobis (= *A. pediculus* = *A. ovalis* var. *pediculus*).

A v a l. 1, 6, 9, 11, 19. C e n t. Red Indian Lake; Buchans and Buchans River. The epithet 'Pediculus' stems back to EHRENBERG (1838), Infus. Tab. xxi., fig. xi) as *Cocconeis Pediculus*. KÜTZING (1849, 'Species Algarum', pg. 59) gives this pagination and figure number under his heading of *Cymbella Pediculus*, which GRUNOW equated later with *Amphora ovalis* var. *pediculus* auct., the diatom now under consideration. In the same work, pg. 50, KÜTZING implies that the EHRENBERG figure was that of a mixture of diatoms, for he refers to EHRENBERG's *Cocconeis Pediculus* again thus: "Infus. Tab. xxi, fig. xi, *ex parte*". The same tacit acknowledgement that KÜTZING realised that EHRENBERG's species included two different diatoms had been seen in 1844. It is necessary for one of the two variants to retain the specific epithet, and this has been done for the diatom so abundant and ubiquitous as *Cocconeis pediculus*. Under Article 76 of the International Code the other parts included in the original have to seek a new name, and we propose *A. Ehrenbergii* as suitable for the *Amphora*. We have already mentioned (1954) that the taxon is of specific rank and should not be retained in *A. ovalis*. P. T. CLEVE, MILLS, A. CLEVE-EULER etc. have all considered that *Amphora perpusilla* is also derived from *C. pediculus* Ktz., e.g. *A. ovalis* v. *pediculus* (Ktz.) GRUN. in A. S. is *A. perpusilla*. A new name for our plant is therefore preferable on this count as well.

*Hantzschia amphioxys* (Ehr.) GRUN. in Cl. & GRUN. has an unusually sparse distribution in Newfoundland.

var. *capitata* Pant. A v a l. Tanglewood. A careful comparison of PANTOCSEK's illustration (1902, pl. 9, f. 243) based on material from Lake Balaton, Hungary, with those of MEISTER (1912, pl. 36, f. 3), a Swiss diatom, and that of HUSTEDT (1930, f. 748) indicates their essential similarity. The usage of *H. amphioxys* var. *capitata* (O. MÜLL.) HUST. in A. S. 1921, and *H. amphioxys* f. *capitata* (O. MÜLL.) HUST. in A. S. 1921, and *H. amphioxys* f. *capitata* O. MÜLL in HUST. 1930 must give way to PANTOCSEK's earlier publication.

var. *pusilla* DIPPEL 1904? GRUN? A v a l. BRIGUS BARRENS; SALMONIER, measuring  $15.5\ \mu$  long,  $3.5\ \mu$  wide. European records known. DIPPEL is usually credited with this variety but reference to his work shows that he attributed it to GRUNOW in his index, and also in the legend to his own fig. 692; in the text, pg. 133, no authority name is appended, an omission which is usually taken in that book to indicate DIPPEL's authorship. This, presumably, led authors to consider he founded the variety. We have been unable to trace the original reference to GRUNOW.

*Stenopterobia arctica* A. CL.-EULER.

A v a l. 3, 9, 10a, 14b, 18a. C e n t. Millertown. These measured  $69\text{--}88\ \mu$  long,  $3.5\text{--}4.5\ \mu$  wide in the middle but only  $1\ \mu$  across at the long produced ends. Costae "Flügelkanäle"  $7\text{--}9$  in  $10\ \mu$ , the transapical striae more than 24 in  $10\ \mu$ . (Fig. 49). cf. WOODHEAD and TWEED 1954.

*Blue-green Algae.*

*Aphanocapsa rivularis* (CARM. ex HOOKER) RABH., A v a l. Hogan's Pond; BRIGUS BARRENS. Upon an examination of the literature we subscribe to this name in preference to *A. biformis* A. Br. in RABH. When GEITLER united this species with *A. biformis* A. Br. in RABH. and *A. paludosa* RABH., he had to select a new epithet from these three which had been used in the same work by RABENHORST and seemingly of equal age; but *A. rivularis* had a far longer history, dating back to 1833, whilst the other two were established in 1865. In the spirit of Article 67 of the International Code it seems correct to maintain *A. rivularis* as the name of the united taxon.

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# The hydrology of Lake Victoria

by

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## INTRODUCTION

Lake Victoria, which is the second largest lake in the world, is situated in British East Africa, between Uganda, Kenya, and Tanganyika (see map Fig. 1). The first attempt at a comprehensive description of the hydrology of the lake was that of FISH (1957) who reviews the previous rather scanty literature. Since the publication of FISH's report, however, the present author has had the opportunity of further investigation into the hydrology of the lake, and the results of a year's observations strongly suggest a reappraisal of FISH's findings.

FISH (and later, TALLING 1957) made use only of a RÜTTNER (1953) sampling bottle, estimating water temperatures between sampling depths by interpolation. This led him to conclude that Lake Victoria was thermally stratified into only two layers. He also made his observations almost entirely at the northern end of the lake, and deduced the gross water movements from the data collected there. The present author was more fortunate in having the use of a Spilhaus type bathythermograph and the assistance of the Lake Victoria Fisheries Service in covering the entire length and breadth of the lake. The results obtained indicate that the lake is, in fact, triply stratified and that the gross water movements cannot be inferred from events observed at only one point in the lake.

## THE EXISTENCE OF AN INTERNAL SEICHE

The main conclusion of FISH was that a uninodal internal seiche operates in Lake Victoria between about September and April. A

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Fig. 1. Lake Victoria.

calculation of the seiche period based on the formula of WATSON (MORTIMER, 1952), using the densities of epilimnion and hypolimnion observed in October — December 1952 and March 1953, and assuming the lake to be two-layered, gave periods of 43.3 and 38.5 days respectively. FISH claims that the vertical oscillation of isotherms observed by him corresponded approximately to these periods. However on close examination of Figures 4 and 5 in FISH's report (1957), it is apparent that the oscillations of the isotherms in the northern end of the lake (at the "Open Lake Station") are by no means regular, whilst on occasions the oscillation of the upper and lower isotherms are in anti-phase. Furthermore, Figure 10 in FISH's report, which shows the alteration in depth with time of various isotherms at the Open Lake Station ( $00^{\circ}11'S.$ ,  $33^{\circ}00'E.$ ), and at a station near Godziba Island in January/February 1954, indicates a more rapid rise of the isotherms at Godziba Island than fall of the isotherms at the Open Lake Station. The amplitude of oscillations at Godziba Island is also greater than that at the Open Lake Station.

Were these oscillations due to a uninodal internal seiche, they should be in phase and of lesser amplitude at Godziba than at the Open Lake Station, since the former location would be nearer the "fulcrum" of the seiche.

The operation of an internal seiche involves a transformation of energy (originally derived from the wind) from potential to kinetic form and back in each half cycle. There is a critical relationship between the energy involved and the stability (i.e. density gradient) of the lake, and should the stability be too low the micro-turbulence caused by the horizontal and vertical motion of the water grows to such proportions that the stratification of the lake breaks down (MORTIMER, 1952). The relationship can be expressed as a function of the velocity of the water and the density gradient, and is given by GOLDSTEIN (1931) as

$$a^2 = 4 g B$$

Where  $a$  is the vertical velocity gradient between epilimnion and hypolimnion

$g$  is acceleration due to gravity.

and  $B$  is (approximately) the density gradient.

(Density gradient =  $B\rho$  but  $\rho$  is effectively unity in the case of water).

The average horizontal velocity of the epilimnion and hypolimnion can be estimated, given the dimensions of the lake, the period of the seiche, the depth of the thermocline, and the amplitude of the seiche, by a calculation of the gross transport of water through the cross-section of the lake at the node, in one half cycle. Multiplying by  $\pi/2$  gives the peak velocity which occurs at each  $\frac{1}{4}$  cycle and  $\frac{3}{4}$  cycle of the seiche (when the thermocline is horizontal).

Assuming the thermocline to be at 30 metres depth, and the amplitude of oscillation to be 10 metres, then since the lake is 250 km long and 60 m deep, a volume of

$$\frac{125 \times 20 \times 10^7}{3 \times 10^3} \text{ c.c.s.}$$

of water flows through each square centimetre of the nodal cross-section in each half cycle of the seiche. This is equivalent to a velocity of 7.6 cm a second. This is a minimum value, since greater amplitudes of vertical oscillation than 10 metres have been observed at the Open Lake Station.

Using the data of FISH for March 1953, of epilimnion density 0.99704 and hypolimnion density 0.99730, with a thermocline occupying a depth of 3 metres, one finds the permissible vertical velocity gradient between epilimnion and hypolimnion to be 17.5 cms/sec. This is very close to the calculated peak velocity difference of 15.2



cms/sec., and suggests that with oscillations of greater amplitude than 10 metres, macro-turbulence and breakdown of the stratifications would occur.

With the knowledge that the lake is actually triply stratified into an epilimnion ( $h_1$ ), metalimnion ( $h_2$ ), and hypolimnion ( $h_3$ ) it is necessary to recalculate the period of a possible seiche, since WATSON's formula no longer holds. Whilst no seiche movement was observed in any of the longitudinal temperature profiles made in the lake during the present author's survey (see Fig. 5), it would be of interest to determine whether, in fact, given the existing density structure and sufficient energy from the wind, a seiche could occur.

Employing the formulae derived by LONGUET-HIGGINGS & MORTIMER (1952) and substituting values for density and layer thickness found in the lake in February 1958, the result is obtained that a uninodal seiche between  $h_1$  and  $h_2$  would have a period of 39 days, and a coexisting seiche between  $h_2$  and  $h_3$  would have a period of 58 days (see appendix). Assuming a vertical amplitude of only 10 metres at the anti-nodes, the maximum velocity difference between  $h_1$  and  $h_2$  would be 24 cms/sec (see appendix). Again using GOLDSTEIN's formula ( $\alpha^2 = 4 g B$ ), with the density gradients obtaining in February 1958 (see appendix), we find that this velocity difference between  $h_1$  and  $h_2$  is considerably in excess of that permissible without instability and breakdown occurring (11 cms/sec.). A seiche oscillation would be permissible between  $h_2$  and  $h_3$ , and could conceivably occur due to seismic disturbance, though any internal wave produced by this agency is more likely to be polynodal. It is impossible, however, given the existing density distribution, for any windinitiated internal seiche to occur in Lake Victoria without breakdown of at least the stratification between  $h_1$  and  $h_2$ , and as will be seen in a later section, this never occurs.

Since surface seiches are common on Lake Victoria (some have been analysed and described by BARGMAN (1953)) and are of the uninodal type which commonly accompanies an internal seiche, one must assume that the extreme shallowness of Lake Victoria in relation to its area (ratio of length to depth is 4,000 to 1) causes an unusually high rate of frictional damping. The magnitude of these surface seiches is of the order of several centimetres in association with southerly winds of 10 to 20 metres/sec. The displacement of the thermocline in a stratified lake is related to the surface displacement by the ratio of the densities of epilimnion and hypolimnion and the atmosphere. The last being negligible, the displacement can be expressed as: —

$$\frac{d_h - d_e}{d_e}$$

Where  $d_h$  is density of hypolimnion

$d_e$  is density of epilimnion

With the values of density obtaining in layers  $h_1$ ,  $h_2$ , and  $h_3$  in Lake Victoria, this expression gives a ratio of about 4,000 to 1. Thus the elevation of the surface of the lake at the leeward end by as little as two centimetres, should cause a rise of the thermocline at the windward end by some 80 metres. Since the lake is only 65 metres deep, this would produce upwelling of hypolimnion water at the surface and pronounced mixing.

Similarly, the slope of the thermocline is related to the wind strength by HELLSTROM's equation (given by MORTIMER, 1952):

$$S = \frac{3.7 \times 10^{-2} c \cdot w^{1.8}}{g (d_h - d_e) h_1}$$

Where  $c$  is a constant varying between 1 and 1.5

$w$  is wind speed in metres per second

$h_1$  is the height of the epilimnion

$g$  is acceleration due to gravity

$d_h$  and  $d_e$  are densities of hypolimnion and epilimnion.

For the conservative values of  $c$  equal to unity and  $w$  equal to 5 m/sec, a slope is derived of 1 in 1100, u.e. over the length of 240 kilometres of the lake, the thermocline should rise at the windward end to a theoretical height of 220 metres, again producing upwelling and mixing.

Such pronounced upwelling has never yet been observed in Lake Victoria, suggesting that frictional damping is very high indeed.

Since it is not possible to explain the vertical oscillations of isotherms observed at the Open Lake Station by an internal seiche, we must look to some other cause, and an examination of wind records from Entebbe Airport immediately suggests an alternative explanation. After a period of consistent onshore wind, the lake level at Entebbe (as shown on the Hydrological Department gauge) rises, whilst the thermocline at the Open Lake Station is depressed, the epilimnion showing a degree of mixing dependent on the strength of wind. A prolonged period of off-shore winds sometimes occurs and produces opposite effects.

A particular instance is shown in Figure 2, where the wind records for the 36-hour period preceding the collection of hydrological data (at the Open Lake Station) on December 3rd, 12th, and 17th are compared with the distribution of oxygen and temperature throughout the water column on those days.

Figure 2 indicates that a period of 24 hours of strong on-shore wind on December 2rd/3rd mixed  $h_1$  and depressed the upper thermocline to 120 feet depth. Layer  $h_2$  has been squeezed out (presumably

to the south) in a manner akin to that shown in MORTIMER's models of a three-layered basin (MORTIMER 1952, Figs. 13 & 14). Only a narrow band of about 10 feet is occupied by  $h_2$  water (temperature 76 to 76.5°F) and some marginal mixing with  $h_3$  has occurred at the lower boundary.

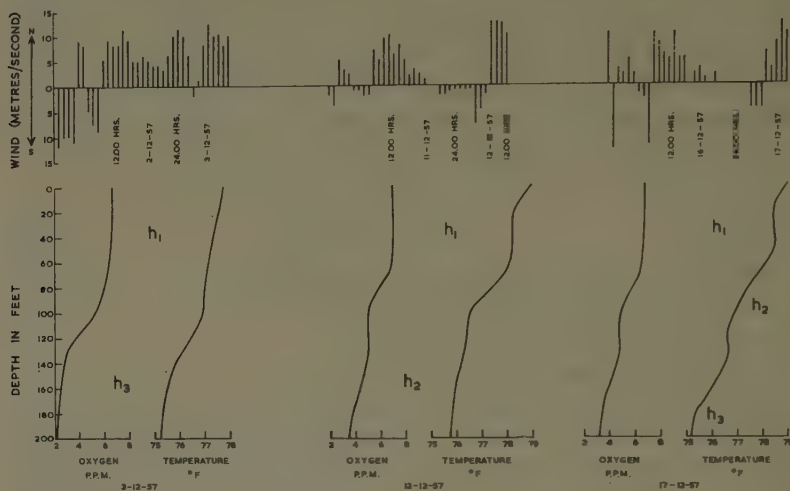


Fig. 2. The changes in the vertical profiles of temperature and oxygen content at the Open Lake Station on December 3, 12, and 17, 1957 in response to wind.

After a night of calm on the 12th the thermocline has retreated to 80 feet depth and the water column beneath this to the bottom is entirely occupied by  $h_2$  water which has flowed north again in response to the lifting of the thermocline with the drop in wind. Layer  $h_1$  has absorbed considerable solar heat and the light alternating winds have partly mixed this layer and accentuated the upper thermocline. That the water beneath the thermocline derives from an incursion of the  $h_3$  layer is indicated by the rise in oxygen content.

After a calm night on the 16th, the water column on December 17th shows its normal, undisturbed stratification. The upper thermocline has remained at 80 feet, whilst  $h_1$  has absorbed still more heat. Some of the  $h_3$  layer has returned between the bottom and 170 feet depth.

#### THE TEMPERATURE CYCLE OF LAKE VICTORIA

Lake Victoria remains thermally stratified into three layers the whole year round, except in the extreme south, where the  $h_2$  layer

occasionally reaches the surface. Table I gives the temperatures at 20 foot intervals of depth for seven months of the year, from bathythermograms taken in various parts of the lake during 1957—8.

TABLE I.

Feet	April	May	June	Aug.	Sept.	Nov.	Feb.
0	76.3	77.6	76.2	76.0	76.0	76.5	77.2
20	76.3	77.5	76.2	75.6	75.8	76.5	77.2
40 <sub>h<sub>1</sub></sub>	76.2	77.4	76.2	75.5	75.4	75.9	77.2
60	76.2	77.4	75.6	75.5	75.2	75.9	76.8
80	76.2	76.3	75.5	75.4	75.0	75.9	76.6
100	75.6	76.0	75.5	75.3	74.5	75.8	76.6
120 <sub>h<sub>2</sub></sub>	75.5	75.8	75.5	75.0	74.5	75.7	76.6
140	75.5	75.6	75.4	75.0	74.5	75.5	76.4
160	75.5	75.5	75.4	75.0	74.5	75.0	75.7
180	74.4	74.5	74.5	74.8	74.5	75.0	75.2
200 <sub>h<sub>3</sub></sub>	74.4		74.2	74.5	74.5	75.0	75.2
220	74.4		74.2	74.5			

Temperatures are in degrees Fahrenheit, and the horizontal lines indicate the approximate depths of the thermoclines.

The upper thermocline ( $h_1/h_2$ ) would seem to be determined by the lower limit of mixing of the surface layer, and its depth varies with wind strength and insolation. The lower thermocline ( $h_2/h_3$ ), however, is akin to the type found in meromictic lakes. Although the vast area of Lake Victoria in comparison with its depth might be expected to result in a relatively high rate of loss of heat through the lake bottom, the thermal capacity of the sea-bed is equivalent to only 1 metre of water. Thus bottom heat loss must be only a minor factor even in Lake Victoria. Furthermore, loss of heat to the bottom would lead to stable stratification of the bottom water and a vertical temperature gradient rather than the uniform layer under a thermocline which is actually found. Two phenomena observed when the tributary streams of Lake Victoria were being investigated suggest a solution. These were the high silicate content of these streams and their low temperature. A small creek entering the Napoleon Gulf at Jinja contained water of lower temperature, pH, and oxygen content than the gulf waters. The creek outflow sank to the bottom on entering the gulf and could be traced as a thin layer over the bottom for some distance from the creek. Similarly, a hydrological section from the mouth of the Kagera River (the principal tributary of the lake), worked in August 1957, showed a layer of water of temperature 74.3—74.5°F extending from the thermocline at 50 feet to the





The annual cycle of temperature change throughout the water column is partly explained by the annual variation in wind regime. Lake Victoria, being situated almost on the equator, is subjected to more or less constant intensity of solar radiation over the year. The cooler air temperatures obtaining between about May and September are mainly due to the preponderance of strong south winds during that period. These same winds, partly because of their high velocity, and also because of their dryness, produce a decrease in humidity and increase in evaporation rate, over the southern half of the lake. In Table II are shown data for relative humidity and mean evaporation rates averaged over several years by the East African Meteorological Department, for four stations round the lake.

TABLE II

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Relative humidity at 0830 hrs.													
Uvanga	} S	79	80	81	81	77	70	65	62	61	61	70	76
Uvanga		74	75	77	80	79	74	79	69	67	63	70	72
Uvanga	} N	77	80	82	83	85	84	87	85	83	89	76	76
Uvanga		85	85	86	86	87	86	86	87	85	82	84	85
Relative humidity at 1430 hrs.													
Uvanga	} S	59	61	63	61	58	50	44	45	49	51	58	61
Uvanga		62	62	63	63	60	59	55	58	58	59	64	62
Uvanga	} N	53	53	59	66	68	64	62	63	60	58	57	57
Uvanga		63	65	69	72	74	72	70	70	68	66	67	66
Mean Monthly Evaporation Rates (m.m.s.)													
Uvanga	} S	56	62	62	52	54	70	96	88	88	76	58	53
Uvanga		104	101	104	81	73	88	105	105	111	124	115	96
Uvanga	} N	62	53	56	42	37	39	50	43	46	57	66	59
Uvanga		48	43	43	36	31	31	36	34	39	45	39	40

In general, evaporation is greatest (given a constant humidity level) when the water surface temperature is higher than that of the overlying air. Hence the diurnal evaporation cycle of the tropics where evaporation is at a maximum overnight.

The nocturnal heat loss from a water surface is essentially a conduction-convection process. Transfer of heat at the waterair interface warms the air layer next to the water. This results in an increased uptake of water vapour by this layer together with instability, causing turbulence. Thus the heat losses by evaporation and conduction are inter-linked. Any factor which augments the turbulence of the air, such as the high winds of the season May to October, increases the rate of heat loss and evaporation.

However, the ratio of heat loss by conduction (sensible heat or

$Q_c$ ) to heat loss by evaporation ( $Q_e$ ) is given by the expression developed by BOWEN (see NEUMAN, 1954 a & b).

$$\frac{Q_c}{Q_e} = K. \frac{T_w - T_a}{e_w - e_a} \text{ (where } K = 61 \times 10^{-5} \text{)}$$

where  $T_w$  is water surface temperature,  $T_a$  the air temperature,  $e_w$  the vapour pressure of the lake surface in millibars and  $e_a$  the vapour pressure of the air in millibars.

Table III shows the average sunrise and sunset air temperatures at E.A.F.R.O., at Jinja, for each month of the year 1957, together with the average monthly water surface temperature at the Open Lake Station for the years 1953 and 1957.

TABLE III.

Month	Ta°C	Ta°C	Tw°C	Tw-Ta	Tw-Ta
	S.R.	S.S.		S.R.	S.S.
January	17	23	25	8	3
February	17	23	26	9	3
March	19	22.5	27	8	4.5
April	18.5	21.5	26	7.5	4.5
May	19.0	22.6	25.5	6.5	3.5
June	17.0	22.0	24.7	7.7	2.7
July	16.5	21.0	24.5	8.0	3.0
August	16.0	21.0	24.0	8.0	3.0
September	17.0	20.5	24.5	7.5	4.0
October	17.0	21.0	25.0	8.0	4.0
November	18.0	22.0	25.0	7.0	3.0
December	16.0	22.5	25.7	9.7	3.2

The Open Lake Station is some 50 miles south of E.A.F.R.O., but the temperature values may be used to give an approximate relationship of  $T_w$  and  $T_a$  over the year. It can be seen that  $T_w - T_a$  is almost constant over the whole year during the nocturnal hours. On the other hand, whilst  $e_w$  is constant,  $e_a$  falls during the season May to October.

Thus the increased heat loss during the season May to October will be almost entirely due to the higher evaporation rate, plus a small increase in  $Q_c$  due to the stronger winds.

The increase in evaporation rate assists in disposing of the large increment of water received by the lake during the heavy rains in April. Lake Victoria reaches its maximum level each year in about May or June, and its minimum in about September or October. In 1953, the average fall of level over this period at eight gauges around the periphery of the lake was 38 cms. (U.D.H.S. Ann. Rep. 1953). The greater part of this excess is voided down the Nile, for the

discharge measurements at Ripon Falls show a doubling of flow in about June or July each year (U.D.H.S. Ann Rep. 1955). Some idea of the amount of this excess water lost by increased evaporation can be derived by measuring the fall in heat content of the water column between the time of maximum temperatures in March and the time of minimum temperatures in August/September. Using FISH's data for 1953 (FISH, 1957, Fig. 4) the net heat loss between those months amounts to some 9,000 gram cal/cm<sup>2</sup>. This is low compared to the annual heat budgets of most temperate lakes, which amount to about 30,000 gram cal/cm<sup>2</sup> (NEUMANN, 1954a).

9,000 gram cal/cm<sup>2</sup> corresponds (at a temperature of 26°C) to the evaporation of about 15.5 cms of water. Some of the heat loss from the water, of course, is consumed by increased backradiation (Q<sub>b</sub>) and conduction (Q<sub>c</sub>), so that the actual amount of excess water evaporated off is rather less than 15.5 cms.

The increased outflow down the Nile in the period after the rains (May to July) also involves a heat loss, since only the warm surface water is drawn off, and the level of the lake is maintained, as we have seen, by an inflow of cold water at the bottom. It is likely that after the rains, the volume of land drainage will be greater (though it is almost impossible to assess the volume) and hence from May to about August the lake will suffer a relative heat loss by the increased advection of cold bottom water.

#### CURRENTS AND WATER MOVEMENTS

Records of wind strength and direction at various stations round the lake kept by the East African Meteorological Department, mostly show a residual south component over the year (e.g. FISH, 1957, Table I), especially in the season May to October. Thus a gradual displacement of surface water to the north is to be expected in the lake. GRAHAM (1929) examined such wind data as were available at that time and came to a similar conclusion. He tested this conclusion by releasing two hundred and seventy one drift bottles (of which ninety six were recovered) on a line from Musoma to Bukoba. The results were complex, but seemed to indicate (GRAHAM, 1929, Fig. 12) a west-north-west drift of water from the centre and south-eastern portion of the lake. This drift diverged near the west coast in the vicinity of Bukoba, sending one branch southwards, and a second north towards the Sesse Island. No bottles were recovered from the north-eastern coast at all.

E.A.F.R.O. has been informed by East African Railways & Harbours that of their two identical steamers on Lake Victoria, either one which makes a clockwise voyage round the lake proceeds



consistently a little faster than the vessel which proceeds anti-clockwise. This supports GRAHAM's conclusions, especially since the steamers proceed directly from Mwanza to Bukoba and thus miss the south-western corner of the lake.

Use of an Ekman current meter during 1957 and 1958 has produced some interesting results. Unfortunately, only three stations were occupied at any distance out into the lake. The rest were occupied at either the Open Lake Station or the 'New Lake Station' (a position mid-way between Baga Rock and Ziro Island, and about 10 miles south-south-east of Bugia Island, see Fig. 1).

The results are given below in tabular form and chronological order.

TABLE IV.

12th December, 1957				New Lake Station	
Time	Depth	Direction	Velocity cms/sec.	Wind	Layer
11.15	Surface	000°	10	SE/SW	—
12.00	20 metres	300°	6	"	h <sub>1</sub>
Thermocline (25 metres)					
11.30	40 metres	340°	6.5	"	h <sub>2</sub>

TABLE V.

17th December, 1957				Open Lake Station	
Time	Depth	Direction	Velocity cms/sec.	Wind	Layer
10.45	Surface	320°	12	SW	
11.10	10 metres	300°	9	"	h <sub>1</sub>
12.30	20 metres	280°	7.5	"	
Thermocline (23 metres)					
12.15	30 metres	250°	9.5	"	h <sub>2</sub>
11.55	40 metres	250°	11	"	
Thermocline (46 metres)					
11.30	52 metres	180°	8.5	"	h <sub>3</sub>

TABLE VI.

24th December, 1957			5 miles due west of Lolui Island		
Time	Depth	Direction	Velocity cms/sec.	Wind	Layer
11.45	20 metres	—	Nil	SW	
11.45	20 metres	—	Nil	"	
11.35	30 metres	—	Nil	"	h <sub>1</sub>
11.20	40 metres	—	Nil	"	
11.00	50 metres	—	Nil	"	

The water column was isothermal from top to bottom on this day. A very slight north drift of surface water was observed.

TABLE VII.

Time	3rd January, 1958 Depth	Direction	Velocity cms/sec.	Open Lake Station Wind	Layer
10.45	Surface	Variable	—	Variable	} h <sub>1</sub>
13.10	Surface	320°	8	S	
11.00	10 metres	270°	8	Light SE	
12.55	10 metres	320°	8	S	
11.30	20 metres	230°	12.5	S	
Thermocline (25 metres)					
11.55	30 metres	290/160 (SW)	6	S	} h <sub>2</sub>
12.15	40 metres	190/040 (SE)	6	S	
Thermocline (48 metres)					
11.20	50 metres	220°	8	SE	} h <sub>3</sub>
12.35	54 metres	280°	12.5	S	

TABLE VIII.

Time	21st February, 1958 Depth	Direction	Velocity cms/sec.	Wind	Layer
17.00	Surface	070°	9	SW	} h <sub>1</sub>
16.30	44 metres	210/140°	11	SW	
16.45	44 metres	290/200°	11	SW	

TABLE IX.

28th February, 1958			Position 15 miles due S of Hunter Rock		
Time	Depth	Direction	Velocity cms/sec.	Wind	Layer
09.55	Surface	020°	22	E	h <sub>1</sub>
10.30	Surface	000°	24	E	
10.40	10 metres	020°	17	ESE	
Thermocline (41 metres)					
10.55	50 metres	130°	17	SE	h <sub>2</sub>
Thermocline (53 metres)					
10.10	60 metres	Variable	—	E	h <sub>3</sub>

An interesting fact to be noted from Table IV is that on December 12, h<sub>2</sub> water was in fact moving north, as was deduced indirectly from the data in Figure 2.

The measurements on the 24th December (Table VI) indicate

that when the whole water column is occupied by  $h_1$  water, no currents are detectable. Presumably a steady state had been reached on that date.

Table VII shows that the currents in the lake depend directly on the wind. At 10.45 hrs, when the wind was very light, no surface current could be detected, though at 11.00 hrs a westerly drift of 8 cms/sec. was observed at 10 metres when the wind had settled in the SE. By 13.10, the wind was fairly strong from the south, and the surface drift had increased to 8 cms/sec. in a direction steadily north-west. It would thus seem that even though there may be a net transport of surface water from south to north, this drift is very slow and possibly occurs in stages, being accelerated in the north by the afternoon-onshore breeze. In Figure 5 are indicated the dynamic heights at each station, calculated by the method of AYERS (1951) and expressed as dynamic metres relative to a reference level at a depth of 60 metres. It can be seen that the dynamic heights are slightly greater at the northern end of the lake than in the centre, suggesting an accumulation of warm surface water in the north of the lake.

It will be noticed that in all cases apart from December 12th and 24th, which are exceptional for reasons already described, a northward transport of surface water is accompanied by a more or less southward movement in the  $h_2$  and  $h_3$  layers.

This movement may be partly phasic in response to the accumulation of surface water, but Figure 5 shows that there is a tendency for the oxygen content of the  $h_3$  layer to diminish towards the south, so that there may be a residual mass movement of deeper water southwards. In this connection it may be significant that at most stations on the lake where water samples were collected, there was found a layer of loose flocculent mud some 2—3 metres thick above the real bottom. Since this floc settles on standing, there must be some motion in the  $h_3$  layer to keep it in suspension.

It has been estimated (U.D.H.S. Annual Report, 1951) that Lake Victoria loses some 20 milliards of water per annum down the Nile, and about 90 milliards by evaporation. Equilibrium is maintained by the gain of some 100 milliards of water per annum from precipitation and 10 milliards from river inflow and land drainage. Since the  $h_3$  layer does not show a continuous increase in extent it is obvious that the 10 milliards introduced by river and land drainage must eventually find its way to the surface.

In view of the persistent thermocline between  $h_3$  and  $h_2$  over most of the lake, it would seem that mixing of  $h_3$  water with the overlying strata occurs in very limited areas, and such evidence as exists suggests that this mixing occurs at the extreme south end of the lake.





3, which was opposite (and to the south-east of) the Kome Channel, the whole water column was occupied by a body of water having a temperature gradient of lower magnitude than the stations on either side, and with no  $h_1/h_2$  or  $h_2/h_3$  interface.

A station worked on the return leg of this cruise (from Bukoba to Jinja) about 10 miles west of Station 3, and 4 days later, showed a similar phenomenon except that the  $h_1$  layer was quite distinct, and only the lower  $h_2/h_3$  thermocline had disappeared.

This phenomenon was not observed at stations worked in this area on cruises in August, September, and November 1957. In those, the only noticeable difference in the distribution of isotherms at such stations was an increase in depth of the  $h_1$  layer relative to stations on either side.

Thus it may be that at certain times of the year, not yet exactly known, a 'river' of mixed water debouches from the Kome Channel in a SE direction.

#### LAKE LEVELS

The Uganda Department of Hydrological Survey maintains nine gauges around the periphery of the lake. If the monthly mean levels of all these gauges are plotted against time as nearly as possible on the same co-ordinates (i.e. by subtracting a constant amount from each individual gauge to compensate for the different lengths immersed in the water) then a general annual cycle emerges. The lake level rises during the main rains in April, remains high in May and June, and declines through the rest of the year. If the changes in level were equal at each gauge, the curves thus plotted should be parallel. In fact they are not, and secondary curves may be constructed which show the annual variation of differences in level between the gauges. This can be done either by subtracting one gauge reading from all the others or by comparing the gauges in pairs. Both methods were used for the years 1955, 1956 and 1957, and it became apparent from the difference curves that a fluctuation in level between north and south is the dominant feature.

This phenomenon is demonstrated in Table X. Part A shows the monthly mean levels for Entebbe, Bukoba, Musoma and Ukerewe (see Fig. 1) for 1957, with the annual change in level due to the rains. (Readings are in metres).

Part B shows the changes in level at Entebbe, Bukoba and Musoma, relative to Ukerewe. It can be seen that between January and July there is a rise of 16 cms. at Entebbe, 17 cms. at Bukoba, and 19 cms. at Musoma, relative to Ukerewe. Continuous records of

TABLE X.

	A											
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Entebbe	10.36	10.41	10.37	10.48	10.64	10.62	10.51	10.44	10.43	10.40	10.39	10.38
Bukoba	1.88	1.92	1.88	2.01	2.18	2.14	2.04	1.96	1.93	1.91	1.90	1.90
Ukerewe	0.99	0.99	0.94	1.08	1.16	1.18	0.98	0.98	0.97	0.96	0.97	0.96
Musoma	3.93	4.00	3.96	4.06	4.23	4.22	4.11	4.02	4.01	4.00	3.99	3.99
B (Ukerewe subtracted)												
Entebbe	9.37	9.42	9.43	9.40	9.48	9.44	9.53	9.46	9.46	9.44	9.52	9.42
Bukoba	0.89	0.93	0.94	0.93	1.02	0.96	1.06	0.98	0.96	0.95	0.93	0.94
Musoma	2.94	3.01	3.02	2.98	3.07	3.04	3.13	3.04	3.04	3.04	3.02	3.03
C (Bukoba subtracted)												
Entebbe	8.48	8.49	8.49	8.47	8.46	8.48	8.47	8.48	8.50	8.49	8.49	8.48
Musoma	2.05	2.08	2.08	2.05	2.05	2.08	2.07	2.06	2.08	2.09	2.09	2.09

level at Mwanza are unfortunately not available yet to compare with Ukerewe.

Since the gauge levels have been compared without reference to absolute datum, it is impossible to state whether or no the discrepancies are all positive and the lake level at Ukerewe is always lower than that at the other gauges. However, it is apparent that during and after the rains, the north, west and north-east part of the lake rises more rapidly in level than the south-east portion. Part C of Table X indicates that Bukoba, Entebbe and Musoma all change in level at much the same rate.

This more rapid rise in level in the north, west and north-east could either be due to the heavier precipitation there relative to the south, or to the south winds of the season May to October, which accumulate surface water to the west and north.

Since the rainfall at Musoma is much lighter than at either Entebbe or Bukoba, and yet the Musoma lake level rises at the same rate, it would seem that wind currents must play some part. In this case, there is presumably a continuation of the northward surface current clockwise round the north end of the lake, which confirms the information supplied by East African Railways and Harbours, mentioned earlier (page 373).

If the January level at Ukerewe is, in absolute terms, higher than at the other three gauges, then all the discrepancies are not positive, and Ukerewe may rise in absolute level relative to the other three stations between about October and April. Such a rise could be caused by the earlier onset and continuous nature of the rains in the south. The rainy season in the south extends from October to May with no fall off, as opposed to the bi-modal short and long rains in the north (MANNING, 1956).

## SUMMARY

Evidence is presented to show that Lake Victoria is triply stratified the whole year round. The conclusions of FISH (1957) that a uninodal internal seiche operates in the lake is shown to be invalid, and the oscillations of isotherms at E.A.F.R.O. Open Lake Station observed over some years are explained by the day to day wind changes.

It is calculated that an internal seiche could operate between the middle and bottom layers, but not between the middle and surface layers, since any such seiche would break down the stratification. Surface waves of the type which normally induce internal seiches are commonly observed on the lake, so it is concluded that the extreme shallowness and great length of Lake Victoria cause a rapid frictional damping of any incipient seiche.

Lake Victoria has an annual heat budget of about 9,000 gram/cm<sup>2</sup>. This amount of heat is lost between March and August and regained between August and March. The loss of heat is occasioned mainly by the increase in evaporation from the lake in the period May to October, and partly by an increase in conduction and back-radiation. The increase in evaporation rate between May and October assists in disposing of the surplus water derived from the rains in April.

The lowest layer in the lake is believed to derive from the inflow of rivers. This layer mixes with the middle layer at the south end of the lake. An apparent area of mixing is suggested north of the Sesse Islands, also.

Current measurements indicate a general northward flow of surface water in response to the wind. This is accompanied by a compensating flow of the two lower layers southwards. This latter movement is mainly phasic but probably has a small residual component.

Lake level readings from gauges round the lake indicate that the west, north and north-east portions of the lake rise more rapidly in level than the south portion, from April to July.

## RÉSUMÉ

Cette étude montre une stratification permanente du Lac Victoria en trois couches. Elle tend à montrer que la conclusion à l'existence d'une seiche interne uninodale (FISH, 1957) n'est pas valable, et que les oscillations des isothermes observées sont dues au changement du régime des vents d'un jour à l'autre.

Le calcul prouve qu'il est possible qu'une seiche interne agisse entre la couche profonde et la couche moyenne, mais certainement pas entre la couche moyenne et la surface, puis-qu' alors elle detruirait la stratification.

Des vagues du type qui normalement provoque les seiches sont couramment observées sur le Lac Victoria. L'Auteur en conclut que la tres faible profondeur et la forme allongée de ce lac causerait un rapide amortissement par friction d'une éventuelle seiche.

Le Lac Victoria a un bilan calorifique annuel de 9,000 g/cal/cm<sup>2</sup>. Cette quantité de chaleur est perdue entre mars et août. La perte de chaleur est essentiellement due à l'augmentation d'évaporation de mai à octobre et partiellement à une augmentation de conduction et de radiation. L'accroissement du taux d'évaporation de mai à octobre contribue à eliminer le surplus d'eau provenant des précipitations d'avril.

Les causes les plus profondes proviendraient de l'apport des rivières. Les couches profondes et moyennes se mêlent à l'extrémité Sud du lac. Il semble aussi que le mélange se fasse au Nord des îles Sesse.

Le vent provoque en surface un courant dirigé vers le Nord, compensé par un déplacement vers le Sud des deux couches inférieurs. Ce déplacement est surtout periodique mais a aussi une légere composante résiduelle.

Des relevés de niveau tout autour du lac montrent que d'avril à juillet celui-ci s'élève plus rapidement à l'Ouest, au Nord et au Nord-Est qu'au Sud.

## APPENDIX

In mid-lake, in February 1958, the water column was stratified into three layers  $h_1$ ,  $h_2$ , and  $h_3$  of thickness 15, 35, and 15 metres, and density 0.997018, and 0.997296 respectively.

Applying these values to Equation (6) in MORTIMER's article (1952), two roots of  $H^{(i)}$  are obtained, viz  $-0.22$  and  $-0.10$ .

The constants  $B^{(2)}$  and  $B^{(3)}$  may now be calculated from Equation (8) giving the values  $B^{(2)} = -2.46$  and  $B^{(3)} = -5.86$ .

The constants  $A_n^{(2)}$  and  $A_n^{(3)}$  may be calculated from the expressions

$$A_n^{(2)} = \frac{Z}{B^{(2)} - B^{(3)}} \qquad A_n^{(3)} = \frac{-Z}{B^{(2)} - B^{(3)}}$$

if the assumption is made that the system starts from rest and that only the fundamental oscillation (i.e. the uninodal) is considered.



In this case the B terms are zero and

$$A_1^{(3)} = -A_1^{(2)}$$

also

$$\zeta_2 = f_2(\kappa) = Z \cos \frac{\pi \kappa}{e}$$

Z is given an arbitrary value of 10 metres, i.e. the system is considered starting from rest with the upper interface ( $h_1/h_2$ ) displaced 10 metres vertically at the antinoda.

The horizontal velocities within each layer may now be derived from equations A27 and A28 (MORTIMER, 1952, Appendix) and simplify to: —

$$u_1 = 7.1 \sin (1.85 \times 10^{-6} t) - 11.3 \sin (1.25 \times 10^{-6} t)$$

$$u_3 = -2.9 \sin (1.85 \times 10^{-6} t) + 1.9 \sin (1.25 \times 10^{-6} t)$$

$$u_2 = -(u_1 + u_3) \frac{h_1}{h_2}$$

$$= -1.8 \sin (1.85 \times 10^{-6} t) + 4.0 \sin (1.25 \times 10^{-6} t)$$

Hence the velocity difference between layers  $h_1$  and  $h_2$  will be

$$u_1 - u_2 = 8.9 \sin (1.85 \times 10^{-6} t) - 15.3 \sin (1.25 \times 10^{-6} t)$$

and this will have a maximum value of 24.2 cms/sec.

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# Further investigations of the algae of pond margins

by

J. H. EVANS

## I. THE MICROSTRATIFICATION OF ALGAE IN MARGINAL LITTER.

It has been found that there is a decrease in the number of species and in the frequency of cells of viable algae with increasing depth in litter and mud of pond margins (EVANS, 1959) and this agrees with the observations of PETERSEN (1935) and TCHAN (1953). The results obtained by the use of a buried slide technique (EVANS, 1959) for the margins of two small bodies of water can be briefly summarised (Figure 1). Although these observations, and the suggestion that certain algae might descend progressively deeper in marginal litter through the season as the water level of a pond falls (EVANS, 1959) may be of some interest, the most important movements of algal cells are probably those which occur in the upper few millimetres of litter. Vertical movements of algal cells, particularly those of pennate diatoms, over a few millimetres in superficial layers of litter and soil in response to local climatic changes have been studied (EVANS, 1959; PETERSEN, 1935). It was found that the cells of certain algae (e.g. *Pinnularia viridis*<sup>1)</sup>) tended to accumulate on the surface of pond margin litter when conditions were relatively cool and damp, and below the surface during drier conditions or, conversely, when it was raining at the time of collection (EVANS, 1959). This last observation agrees with the account by LUND (1945) of the disappearance of diatoms below a soil surface during a thunder shower.

During the summer and autumn of 1957 and 1958 samples of leaf litter were taken, as previously described (EVANS, 1959), from the margins and the exposed bottoms of ponds on Stanmore Common, Middlesex. Samples of superficial, exposed leaf fragments are refer-

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<sup>1)</sup> For those species for which authorities are given nowhere in the text of this paper, authorities are as cited in EVANS (1958) and in HUSTEDT, F.: Bacillariophyta (Diatomeae) in Pascher's Die Süßwasser-flora Mitteleuropas 10. Gustav Fischer, Jena. 1930.

red to as stratum 1, the fragments immediately below this as stratum 2 and the fragments below these as stratum 3. Each leaf fragment was placed in a sterile, corked tube for transport to the laboratory. To each collecting tube was added 5 ml. sterile, distilled water and, after shaking and allowing to settle, two drops were taken from each tube, one from the water surface and the other from the sediment. These drops were mixed on a slide with a scrape taken with a sharp, sterile scalpel from the leaf fragment. After mounting, a low-power survey was made followed by a count of the number of cells of each species present in fifty fields at  $\times 1,200$ .

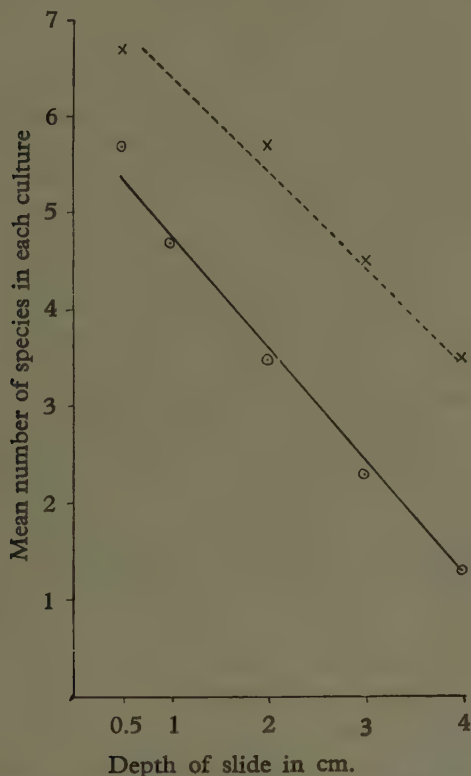


Fig. 1. The decrease in the number of species of viable algae with increasing depth in the litter and mud of the margins of two ponds. Broken line, results for the Englefield Green pond, Surrey, in 1954. Unbroken line, results for the Stanmore Common pond, Middlesex, in 1954.

During this investigation particular attention was paid to one climatic factor, atmospheric humidity. During August and September 1957, on each of twelve days at irregular intervals, samples were taken between 9 a.m. and 11 a.m. On all but one of these days, when



it was raining, the sampling was carried out during periods of full sunlight though it should be added that the sampling area itself was in tree shade. For this series of observations the minimum and maximum temperatures recorded were 58°F and 65°F respectively. Records of relative atmospheric humidity were obtained with a whirling hygrometer about 1 metre above the sampling point.

The results for diatoms in this series of samples (Figure 2) suggest that cells tended to accumulate at the surface, stratum 1, in conditions when the relative humidity was above 70 % and below the surface (only stratum 3 is represented in Figure 2) when the relative humidity was less. When it was raining, there was an accumulation of cells below the surface. All samples were taken within an area not exceeding 0.1 sq. metres and the results indicate a very uneven distribution of cells over the surface with localized accumulations of cells, possibly associated with higher nutrient availability, and consequent high rate of cell division, or possibly resulting from surface migrations of cells horizontally. It was also found that there were local accumulations of certain species of diatoms. One count of 31 cells, for example, consisted entirely of *Pinnularia biceps* f. *minutissima* HUST. This sample had been taken when the relative atmospheric humidity was 74 % and this exceeds what is considered to be the critical level of about 70 % (Fig. 2). In only one of seven samples taken at relative humidities exceeding 70 % was this species detected in stratum 3, and then only one cell was observed in 50 fields at  $\times 1,200$ . On the other hand, no live diatom cells were observed in surface samples (stratum 1) taken when the relative atmospheric humidity was less than 70 %.

The wide variation in sample counts of diatom cells makes comparisons difficult. It is possible, however, to see clear differences (Figure 2) between the numbers of cells present at the surface, above and below a relative humidity of 70 % and a difference between the

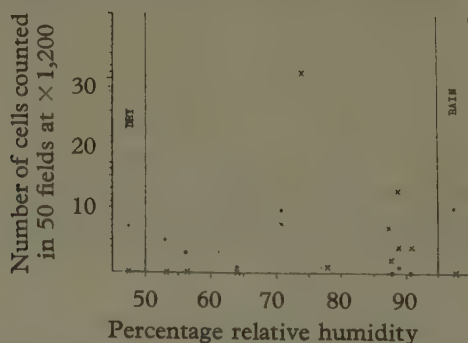


Fig. 2. Frequency of diatom cells in leaf litter from the Stanmore Common pond during the period 27.8.57—17.9.57. x, samples from the surface (stratum 1). •, samples from below the surface (stratum 3).

numbers of surface and sub-surface cells at humidities less than 70 %.

The other diatoms observed in these samples included *Eunotia arcus*, *E. lunaris*, *E. tenella*, *Pinnularia subcapitata*, *P. viridis*, *Gomphonema parvulum*, *Nitzschia palea* and *Hantzschia amphioxys*. Cells of the species of *Pinnularia* were found at the surface at least as often as below it while cells of the other species were rarely found at the surface. This suggests two interesting possibilities. If all or most vertical movements of diatoms in litter and soil are passive, as PETERSEN (1935) suggested, then one might expect the vertical distribution of one species to be similar to that of any other. That this was apparently not so might indicate, at least for the species of *Pinnularia* observed, that there is an active response to changing environmental conditions. Non-motile diatoms, such as *Eunotia*, however, would not be expected to show such an active response to changing conditions. Possibly a greater contribution towards the survival of a species might be conferred by cells which, even though exposed at the surface, are able to resist desiccation. It seems not unlikely, however, that the ability to return to the surface in equable conditions would be of advantage to diatom species.

The most common algal species, other than diatoms, observed in the samples during 1957 were *Chlorococcum infusionum*, *Ulothrix subtilis* and *Microthamnion kützianum*. No cell counts were made for these species, nor for the other non-motile species observed which included *Microspora stagnorum*, *M. floccosa*, *Oedogonium* sp., *Tribonema vulgare* and *T. viride*.

Phytoflagellates were counted but the results obtained were too erratic for any definite conclusions to be made. It is perhaps worth noting, however, that in one series of samples, taken at a relative humidity of 78 %, 10 cells were counted in 50 fields at x 1,200 from the surface sample (stratum 1) while no cells were found in the sub-surface samples (strata 2 and 3). A further series of samples was taken during a period of drying when the relative humidity was 74 % at the start, had fallen to 64 % after 20 minutes and to 56 % after 11 hours. Under these conditions of drying, the flagellate cells showed a more uniform vertical distribution. The number of cells counted for the samples from the strata 1, 2 and 3 were, respectively, 5, 5 and 4. These numbers are very small and might lead to unreliable conclusion, but, bearing this in mind, these results do suggest that, as with the diatoms, there might be an association between relative humidity and the vertical distribution of cells in the uppermost millimetre or so of the litter. The flagellates observed were *Euglena mutabilis*, *E. viridis*, *Lepociclis ovum* and *Cryptomonas ovata*.

There was more rain in 1958 than in 1957, the respective totals recorded at the Meteorological Office in Harrow, Middlesex (about

4 miles from Stanmore Common), being, approximately, 34.8" (88.2 cm.) and 23.3" (58.8 cm.) of which 26.2" (66.5 cm.) and 16.9" (42.7 cm.) respectively had fallen by the end of September. Entirely or largely as a consequence of this, the water levels in Stanmore Common Ponds were very high in the autumn of 1958. At the body of water referred to as the Stanmore Common pond (EVANS, 1958, 1959) the water level was the highest since observations were begun in April 1953. There was no exposure of the bottoms of ponds and little of the marginal litter throughout the summer so that too few samples could be taken to give conclusive results. Of the diatoms, only *Pinnularia viridis* was observed in 1958 in this habitat, and this species is to be regarded as being more adapted to an aquatic existence than to exposure, though it has been suggested (EVANS 1958) that it will survive some exposure in nature.

## II. DRYING EXPERIMENTS WITH DIATOMS.

It has been found that the algal flora of the litter of the margins of certain small ponds shows a rapid decrease when the moisture content of this litter reaches about 50 % of the wet weight (EVANS, 1959). Little is known of the critical moisture content, below which species will not survive, for individual species of algae, and less is known about the condition of individual diatom cells under drying conditions. Many workers have, however, reported the accumulation of granular bodies or oil globules in organisms exposed to desiccation (DENFFER, 1949; FRITSCH, 1916, 1944; HEIDE, 1939; KAHN, 1949; PETERSEN, 1935; PIERCY, 1917; SALAH, 1952).

In March 1958 series of drying experiments were begun to investigate the effect of drought on diatom cells. The results for cultures which were later found to be heavily contaminated with fungi or bacteria were discarded. Though the species in the following account were originally collected from the field, attempts were made to deal with diatoms as uni-algal cultures. To achieve this, methods based on those described by PRINGSHEIM (1946) were used. Diatoms were inoculated onto various types of surfaces to find the medium upon which the species concerned grew the most rapidly and naturally. Plain agar, agar with organic and with inorganic additions were tried as well as damp, sterile sawdust, sand, soil, mud and litter. In March 1958, mud was collected from the margin of a Hertfordshire pond that I have called the Rowley Green 'normal' pond (EVANS, 1958). The mud was placed to a depth of about 2.5 cm. in each of two covered crystallising dishes (10 cm. diameter, 5 cm. high) which were autoclaved at 20 p.s.i. for 30 minutes. One dish, A, was inocu-

lated with a sample from a mixed, soil-extract culture containing three species of *Pinnularia* (*P. viridis* (NITZSCH) EHR., *P. mesolepta* (EHR.) W. SMITH and *P. biceps* f. *minutissima* HUST.), in addition to *Euglena mutabilis*, SCHMITZ. The other dish, B, was inoculated with a sample taken from the margin of the Stanmore Common pond, Middlesex (see EVANS, 1958). The dishes were kept in a north light. In dish A, living cells of *P. viridis* were not found by subsequent observations. By the end of 1958, there remained *P. mesolepta* in small numbers and *P. biceps* f. *minutissima* HUST., which was co-dominant with *Euglena mutabilis* (Figure 3 A). In dish B, by the middle of June 1958, a patch of cells about 2 cm. in diameter, of *Navicula cryptocephala* KUTZ occupied the centre. A few filaments of *Anabaena variabilis* KG. emend. GEITL. were found at this time and by the end of the month the blue-green alga was spreading from the centre and replacing the diatom. By the end of December the filaments of *Anabaena* had spread over most of the mud surface (Figure 3 B i) and by March 1959 the diatom was restricted to the edges (Figure 3 B ii). *Euglena mutabilis* in dish A tended to migrate towards the light side of the dish but did not replace the diatom, while the blue-green alga in dish B apparently grew with little if any regard for the direction of light but did successfully replace the diatom.

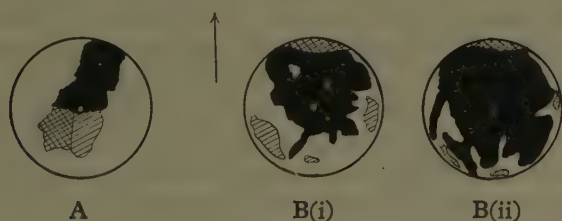


Fig. 3. Algal growth on the surface of damp mud in glass dishes. A, dish A, 9 months after inoculation. Solid black, area covered by *Euglena mutabilis*, SCHMITZ; shaded, area covered by *Pinnularia biceps* f. *minutissima*, HUST.; cross-shaded, part removed for experiments. B, dish B, after (i) 9 months and (ii) 12 months. Solid black, area covered by *Anabaena variabilis* KG. emend. GEITL. shaded, area covered by *Navicula cryptocephala* KUTZ and *Nitzschia palea*, GRUN.; Cross-shaded, part removed for experiments. Point of inoculation marked thus, ⊙. The arrow points towards the source of north light.

In mid-November 1958 in dish B, when the moisture content was still as high as 70 % (expressed as a percentage of the wet weight), a few isolated cells of *Nitzschia palea* were found intermingled with the *Navicula cryptocephala*. By the end of March 1959, when the moisture content had fallen to 58 %, *Nitzschia palea* had increased considerably. A scrape was taken where the diatoms showed a



macroscopically visible growth and the relative frequency of the two diatoms was calculated. Of 270 cells counted 62 % were of *Nitzschia palea*. This increase of *N. palea* during drying confirms earlier observations (EVANS, 1958, 1959) and agrees with the results of LUND (1942).

The mud cultures were used as a source of diatoms for drying experiments during 1958 and early 1959. Small, surface samples, to a depth of about 2 mm., of an air-dry weight between 0.02 and 0.3 gm., were taken from time to time. These small samples were allowed to dry in paper containers, of known weight, in an incubator maintained constantly at 23°C., and with light at 200 metre-candles. from 8.30 a.m. to 6 p.m. The samples were reweighed at three-hour and four-hour intervals during every day (between 9 a.m. and 8 p.m.) until they showed no further decrease in weight. Fragments, regarded as of negligible weight for the purpose of these experiments, were removed from the surface of each small sample, at the same time intervals, and placed in soil extract culture in sealed, sterilised, pyrex-glass test tubes.

In the last, and most comprehensive series of these experiments, begun in November 1958, the moisture content of the mud was initially 70 % (of the wet weight). Three samples, each to a depth of about 4 mm., were taken from each dish; a 'large' sample (about 0.3 gm. dry weight), a 'medium' sample (about 0.15 gm. dry weight) and a 'small' sample (about 0.02 gm. dry weight). It was found, as was expected, that the largest sample lost water the least rapidly. The soil extract cultures which had been set up during the drying of the samples were examined after 10 days, 18 days and 30 days. Each tube was shaken vigorously for one minute, one drop was removed and mounted under a  $\frac{7}{8}$ " square coverslip and the number of cells present in 50 fields at x 600 were counted. To check the accuracy of this rather simple method, counts were made in duplicate or triplicate for some samples. No statistically significant differences were ever found for counts in duplicate or triplicate.

From the results it is possible to discover the critical moisture content below which cells, of the species dealt with, tend to lose their viability. In Figure 4 the results for *Pinnularia biceps* f. *minutissima* and *Navicula cryptocephala* are shown together. It is clear that there is a decline in viability of *Pinnularia biceps* f. *minutissima* during drying and that below a moisture content of 50 % the viability falls off markedly. The development of fewer cells of *Navicula cryptocephala* makes comparisons difficult but it would appear that a similar decrease in viability occurs. These results confirm observations made during 'large-scale' drying experiments (EVANS, 1959) when it was found that below a moisture content of about 50 % a rapid decrease in the algal flora occurred.

Some attention was paid in this investigation to the condition of individual cells. Various staining techniques were used, particularly those of value for detecting fat. In addition, three separate tests (Ferric chloride; potassium dichromate; ammonium chloride and ammonium molybdate) gave negative results for tannins. The Sudan stains were used, especially Sudan black, and amongst other methods a modification of that described by BRADLEY (1957). Cells were treated with acetocarmine for a few minutes while warming gently, followed by a saturated solution of Sudan black in 45 % acetic acid.

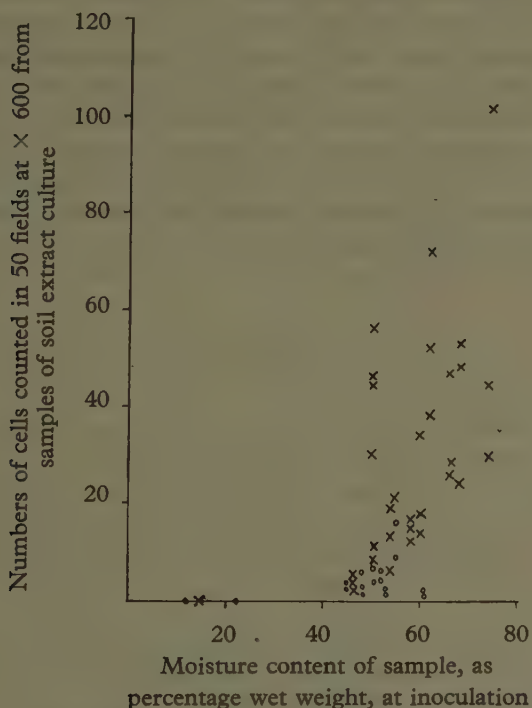


Fig. 4. Recovery of diatom cells subjected to drying and then placed in soil extract culture.

x, counts of cells of *Pinnularia biceps* f. *minutissima*, HUST., after 10, 18 and 30 days.

o, counts of cells of *Nacivula cryptocephala*, KÜTZ., after 10, 18 and 30 days.

It was found that in the fresh, damp state, at a moisture content of about 70 %, some cells contained conspicuous fat globules (Figure 5 B). Even in the early stages of the drying experiment some changes occurred. In the small samples the moisture content dropped in the first 6 hours to 60 % or even as low as 50 % in two experiments. A comparison of cells in the fresh state (Figure 5, B and F), however,

indicated that some cells showed marked changes at an early stage in the drying. Conspicuous fat globules developed in some cells of the two species investigated when the level of moisture content was still relatively high, e.g. cells of *P. biceps* f. *minutissima* at a moisture content slightly below 70 % (Figure 5 C). Such cells underwent no apparent change at lower moisture levels and were observed in subsequent liquid cultures (Figure 5 G) whereas cells lacking fat globules became plasmolysed, and did not recover when placed in liquid culture. This suggests that fat-containing cells are more likely to survive drying than fat-free cells. This agrees with many previous observations (DENFFER, 1949; FRITSCH, 1916, 1944; PETERSEN, 1935). The protoplast of some cells of each of the species examined had a peripheral layer which became black in Sudan black suggesting the presence of an outer layer of a fatty nature (Figure 5 D, H). Such a condition is, perhaps, comparable with that described for cells of *Zygogonium ericetorum* by FRITSCH (1916). The existence of a peripheral fatty layer might possibly increase the chance of survival of a diatom cell during dry conditions.

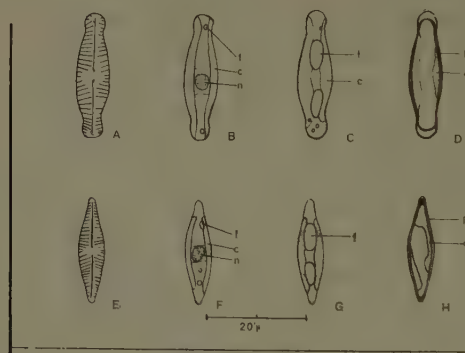


Fig. 5. Two species of diatoms and their cell inclusions.

A-D, *Pinnularia biceps* f. *minutissima*, HUST.

E-H, *Navicula cryptocephala*, KÜTZ.

A and E, the frustules.

B and F, cells in the fresh state.

C, cell after about 6 hours drying to a moisture content a little lower than 70 %.

D, cell after drying to a moisture content of 62 %.

G and H, cells recovering in soil extract culture, G after drying to 62 % and

H, after drying to 61 %.

c, chromatophore; f, fat globule; n, nucleus; p, dark, peripheral layer.

In September 1959, nearly a year later, the mud in both dishes appeared to be very dry. Three small samples (0.2—0.6 gm. each) were taken from dish B and the moisture contents determined as 28 %, 35 % and 43 %. Small fragments of surface mud from both

dishes were placed in Chu 10 culture solution and it was found after 19 days in this medium that *Pinnularia biceps* f. *minutissima* from dish A had remained viable. In the Chu 10 culture inoculated with a small sample from dish B, only *Nitzschia palea* appeared. This suggests that *Navicula cryptocephala* failed to survive the more prolonged dry period or that it failed in competition with *Nitzschia palea* which is known to be a drought resistant form (EVANS, 1959).

Many of the cells of *Pinnularia biceps* f. *minutissima* taken from the dried mud surface in dish A contained oil globules while some cells possessed a peripheral layer, similar to that observed during the initial drying, which stained with Sudan black. In Sudan III this layer appeared dark orange-red and was still visible when using a x 15 ocular and an apochromatic 2 mm. oil immersion objective, which makes it less likely that this layer was no more than an optical artifact. The protoplast of all cells which did not possess this layer shrank markedly in 70 % ethyl alcohol. This clearly suggests the protective nature of such a layer which might, perhaps, be regarded as a fatty cuticle. The survival of this species during dry periods might depend very largely upon the ability of at least some of the cells to produce such a layer.

#### SUMMARY

There appears to be an association between the relative humidity of the atmosphere and the vertical distribution of certain diatoms in the uppermost few millimeters of leaf litter at pond margins. Cells tend to accumulate at the surface when the relative humidity exceeds 70 % and below the surface at lower relative humidities.

There are indications also that the vertical distribution of flagellates might be associated with relative humidity.

Diatoms and other algae have been grown on a variety of media, particularly damp, sterile mud. Culture experiments indicate that the critical moisture content, below which cells of two diatoms, *Pinnularia biceps* f. *minutissima* and *Navicula cryptocephala*, tend to lose their viability, is in the region of 50 % (of the wet weight).

For these two species of diatoms, it would appear that cells which accumulate fat are more likely to survive drying than those which do not. The protoplast of certain cells of these two diatoms appeared to develop a fatty peripheral layer during drying. *Pinnularia biceps* f. *minutissima* remained viable after a further year of drying.

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A. THIENEMANN „Erinnerungen und Tagebuch. Blätter eines Biologen. Ein Leben im Dienste der Limnologie“.

Stuttgart, Schweizerbart'sche Verlagsbuchhandlung, 1959, 499 p. 48 DM (bound).

This book of THIENEMANN is not only of the greatest importance as a biography of a universally known scientist, but must also be considered as one of the foremost contributions to the history of hydrobiology in general.

THIENEMANN was the director of Plön after ZACHARIAS. There he received an enormous number of hydrobiologists from other countries and made the hydrobiological education of several now well-known directors of institutes or stations.

On the other hand it is always a pleasure to read an autobiography of such a great worker, a prominent personality who has exercised a decisive influence on the evolution of hydrobiology and who notwithstanding his leading role always remained a modest man, pleasant to get on and work with.

His very correct attitude towards all his colleagues limnologists of the whole world during the world war II will always stand out as an example of good-fellowship. He is one of those men for whom science is the essential instrument for a loyal and honest international cooperation based on mutual understanding.

It is with the greatest pleasure that one reads such an impressive account of so fruitful a life.

P. VAN OYE

W. KOCH, „Fischzucht. Lehrbuch für Züchter und Teichwirte“. Berlin, Paul Parey, 1960, 322 pp.

In most languages we find treatises on fishery and fish culture and most countries can say that they have some good books on this subject.

KOCH's treatise has already reached its third edition. It is fluently written, abundantly illustrated (216 illustrations) and can really claim to be a practical handbook for fish-farmers.

For those readers who want to have a good German book in this line, it can be recommended.

P. VAN OYE

Handbuch der Pflanzenphysiologie

Encyclopedia of Plant Physiology

herausgegeben von/edited by W. RUHLAND

Band III, vol. III. Pflanze und Wasser/ Water Relations of Plants

Springer Verlag Berlin, Göttingen, Heidelberg, 1956

XXII + 1073 pp. 248 DM, 400 illustrations.

In the Encyclopedia of Plant Physiology, edited by W. RUHLAND, vol. III is of great interest also to hydrobiologists in its widest acceptance. Here we find the water relations of plants but also many subjects that have a direct bearing upon hydrobiology and protistology as for instance:

„Das Meerwasser“ by KURT KALLE: 1. Chemisch bedingte Eigenschaften;  
2. Rein physikalisch bedingte Eigenschaften.  
„Das Wasser in der Atmosphäre als Nebel und Niederschlag“ by RUDOLF  
GEIGER, „Niederschläge die sich an Oberflächen bilden“.

F. J. VIEHMEYER „Soil Moisture“.

Also of great interest to the algologist and hydrobiologist are: „Wasseraufnahme  
und Wasserspeicherung bei Thallophyten“ by the well-known O. STOCKER.

„Das Tauprobem“ in the chapter by FRITZ GESSNER „Die Wasseraufnahme  
bei Blättern und Samen“.

„Die Transpiration einzelner Formen, Algen“ in the chapter „Die Transpi-  
ration der Thallophyten“ by O. STOCKER.

Very important are: „Der Wasserhaushalt ökologischer Pflanzentypen“:  
A. „Das Wasser als pflanzengeographischer Faktor“ by C. TROLL; B. „Der  
Nebel als pflanzengeographischer Faktor“ also by C. TROLL.

„Der Wasserhaushalt der Hydrophyten und Helophyten“ by FRITZ  
GESSNER. In this chapter we find amongst others „Die spezifische Bedeutung  
der Wurzeln bei Hydrophyten“ and „Die Wasserbewegung in Submersen“.

Quite an interesting chapter is also the one on Halophytes by M. J. Adriani.

We can say that all problems in connection with water and the physiology  
of plants are treated in this volume. As is the case in the whole encyclopedia the  
chapters are written in the three most used conference languages German,  
English and French. In all three the style is concise so that maximum infor-  
mation is brought in the shortest possible text.

As we see from the above survey, every chapter is the work of a specialist.  
In this volume of 906 pages (not including the indexes) there are no less than  
28 collaborators who worked under the editorship of O. STOCKER.

Let us add that the part of „Die wasserführenden Medien“ „I. Das Süß-  
wasser“ is the work of prof. dr. F. RUTTNER.

Vol. III of the Encyclopedia of Plant Physiology brings very valuable in-  
formations to all those who are interested in hydrobiological matters and  
particularly in these with a physiological character. P. v. O.

“Symposium on the Classification of the Brackish Waters”  
Archivio di Oceanografia e limnologia, vol. 11 supplemento.

The reports of this symposium are of the greatest interest for those who  
work in the field of biology of brackish waters. Yet the results, inasmuch as  
they have been the aim of the symposium have not been attained. In the  
general discussion we read a statement by Mr. MACAN:

“Some 30 years ago THIENEMANN and NAUMANN put forward a classification  
of lakes and coined three terms. These have proved useful when applied in a  
general way. Subsequent workers erected a complicated system and many  
new words were invented. Two years ago at the S.I.L. congress in Helsinki  
the whole scheme was reviewed. The sense of the meeting, as it appeared to  
me, was that the classification had got out of hand and a reversion to simple  
general terms was desirable. There seems a danger of a similar course of events  
in the classification of saline waters.

I would put before this assembly the thought that we might be trying to  
classify too exactly something not susceptible to exact classification.”

Since the improvement REDEKE brought in 1933 to my classification of  
1920, we have possessed a system that allowed to treat brackish waters in such  
terms that anybody can understand what it is all about and anyone can make  
local subdivisions.

It is a utopia of trying to have one classification for the whole world, and  
this will be the case for all other kinds of classification.

P. VAN OYE.

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